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Proceedings...

Nineteenth National Potato Utilization Conference

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July 28-29, 1969
Ferris State College
Big Rapids, Michigan

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

The Nineteenth National Potato Utilization Conference was held in conjunction with the 53d Annual Meeting of the Potato Association of America during the week of July 27, 1969, on the campus of Ferris State College, Big Rapids, Michigan. The papers in these proceedings are those that were presented during the utilization conference July 28 and 29. Papers presented at the association meeting July 30 and 31 will appear in the American Potato Journal.

Apart from the consumer dialog, which was transcribed from a tape recording made at the conference, the material in these proceedings was provided by the speakers as a written copy of the talks they presented. Statements made in the papers are the speakers' own and do not necessarily represent the views of the U. S. Department of Agriculture. References, figures, and tables are reproduced essentially as they were supplied by the speakers. Numbers in parentheses refer to References at end of each paper. Mention of commercial products does not imply recommendation by the U. S. Department of Agriculture.

Sponsors of the Conference

Michigan State University
Michigan Potato Industry Council
Michigan Crop Improvement Association
United Fresh Fruit and Vegetable Association, Potato Division
U. S. Department of Agriculture

This report prepared at the

Eastern Utilization Research and Development Division

Agricultural Research Service

U.S. DEPARTMENT OF AGRICULTURE

600 East Mermaid Lane

Philadelphia, Pennsylvania 19118

December 1969

NINETEENTH NATIONAL POTATO UTILIZATION CONFERENCE

Ferris State College
Big Rapids, Michigan

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INTRODUCTORY AND WELCOMING REMARKS

The Nineteenth National Potato Utilization Conference was opened by several brief messages of welcome and introduction. The welcome to Ferris State College was brought by Dr. Merle R. Murray, Acting Dean, School of General Education. Dr. Murray expressed regret that neither Dr. Victor F. Spathelf, President, nor Dr. Robert L. Huxol, Vice President, was able to be present at the opening of the conference. Both, he explained, were engaged in meetings to plan for Ferris State's new medical building which is to be erected to house the college's medical science and arts program. Dr. Murray briefly sketched the history of Ferris State College, and provided an outline of the curriculum it offers. He pointed to the school's phenomenal growth in recent years and drew attention to its building program which is still in progress.

* * * * * * *

After Dr. Murray's remarks, the following welcome to the conferees was brought on behalf of the U. S. Department of Agriculture, one of the sponsors of the conference:

Welcome

William P. Ratchford, Acting Director
Eastern Utilization Research and Development Division
Agricultural Research Service, USDA
Philadelphia, Pennsylvania 19118

I take pleasure in welcoming you to this 19th National Potato Utilization Conference on behalf of the U. S. Department of Agriculture, and specifically on behalf of the Eastern Utilization Research and Development Division in Philadelphia where the first of these informative and stimulating conferences was held in 1948.

Things have not been quite the same in Philadelphia since last February 28, when Dr. Perce Wells retired after serving as Director of the Eastern Division for more than 30 years. We are indebted to him for his leadership in the productive and successful research of our Division, and for the momentum generated by his energy and enthusiasm. In the past few months we have appreciated this momentum that has kept us moving in a period of transition. Perce took a special interest in the Potato Utilization Conference, and I am sure I express the sentiments of all who have been connected with it through the years in wishing him and Grace a long and happy retirement.

In Philadelphia, we are awaiting the arrival of our new director, Dr. Ivan A. Wolff, from the Northern Utilization Research and Development Division in Peoria, Illinois. I am sure I can speak for Dr. Wolff in welcoming you today and in assuring you of our continued interest in this conference and our belief in the importance of the research on potatoes being undertaken by both the Eastern and Western Utilization Research and Development Divisions, the Market Quality Research Division, and the Transportation and Facilities Research Division, as well as by our land-grant universities and agricultural experiment stations, and by industry.

The other day I was looking over the proceedings of the first conference on potatoes held at our laboratory in Philadelphia almost 21 years ago. At that time potato flakes and improved potato granules were still far in the future. The conference included only one general paper on the dehydrated and frozen products that have since provided such an enormous stimulus to consumer demand for potato products. Industrial and feed uses of potatoes had a large and important place on that conference agenda.

It is interesting that one of the papers given at that first conference dealt with the same subject as one being given at this 19th: potato starch factory wastes. Then we had to admit that we knew no economical way of recovering the solids from the protein water given off in making this starch. This afternoon we will learn of the progress being made in recovering amino compounds and valuable organic acids and phosphates from this waste, using reverse osmosis and ion-exchange techniques. Thus the national concern about pollution has encouraged us to try again what could not be done two decades ago, and we seem on the threshold of success through application of today's advanced technology.

This is a good example of the progress being made each year in potato processing technology. We are proud to have a part in sponsoring these conferences where such scientific information can be exchanged for the benefit of the entire potato industry.

My best wishes to you for another successful conference.

* * * * * * *

Greetings were also extended to the conference by Dr. Donald R. Isleib, President, Potato Association of America, whose 53d annual meeting was held July 30 to August 1, immediately following the Potato Utilization Conference. Dr. Isleib expressed his appreciation for the accommodations made available by Ferris State College for both meetings. He also observed the common interest of his association and the Potato Utilization Conference in bringing producers and processors the information they need to supply consumers with an adequate supply of quality potatoes and potato products.

* * * * * * *

Bringing greetings to the conference from its academic sponsor, Michigan State University, was Dr. Dale Harpstead, Chairman, Department of Crop and Soil Sciences. Dr. Harpstead, who has been working on problems of hunger and malnutrition in Colombia, remarked on the tremendous responsibilities of those involved with food production to meet the crisis of starvation facing most countries of the world. With the population of South America, for example, expected to double by the year 2000, he said the goal of meeting the food needs of these added millions is one that must be met quickly, and one that cannot be passed on to someone else.

AGRICULTURE FOR THE TWENTY-FIRST CENTURY*

S. H. Wittwer, Director
Michigan Agricultural Experiment Station, Michigan State University
East Lansing, Michigan 48823

The technological achievements of recent years have no historical parallel. Never has so much transpired so rapidly. The biological sciences and agriculture have played dominant roles in this progress. A dozen major discoveries in biology have recently been enumerated (21). The agricultural revolution in the United States had its beginning in the late 1930's and early 1940's. In sheer accomplishment it is one of the great events of modern history.

Many projections have been made for the advent of the 21st century, the terminus in much of our planning. The year 2000 will see, it is projected, unlimited atomic power, interplanetary travel, sea farming, an abundance mined from the bottom of seas and lakes, an almost total conversion to synthetic and/or processed convenience-type foods, regional weather control, and the synthesis of life.

To project events, accomplishments, and progress in agricultural technology is dangerous. All projections heretofore for crop productivity have fallen far short of true accomplishments (8). More important still than that which we predict is the unpredictable. Twenty-year projections in 1937 missed the following major discoveries: radar, antibiotics, jet propulsion, and atomic energy.

This paper projects agriculture for the 21st century. It draws heavily from our earlier report on biological limits in crop and livestock productivity (67), and from summaries of progress in research and technology on the food supply in the United States (69, 70).

Food Production

This Nation has recently achieved the greatest food production record in the history of mankind. Only within the last 30 to 35 years have crop yields increased substantially (48). For 140 years (1800-1940) yields of corn, the number one crop in the U. S., remained at 22 to 26 bushels per acre. Since 1935-40, however, yields of corn, grain sorghum, potatoes, and tomatoes for processing have quadrupled. Those for wheat and soybeans have doubled. Milk production per cow has increased each year for the last 20 years, and the slope of the yield curve is progressively more precipitous. New highs have been achieved in the production efficiency of eggs, broilers, turkeys, pork, and beef.

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*Presented by Dr. Gordon E. Guyer, Chairman, Entomology Department, Michigan State University, East Lansing, Michigan. Journal Article No. 4795 from the Michigan Agricultural Experiment Station.

Abroad, production records are equally impressive. Japan had a bumper rice crop in 1968, and for the first time in modern history had a surplus. Italy has a quarter million extra tons. South Vietnam is once again near rice self-sufficiency. Taiwan and South Korea, both with major food problems a few years back, now meet their own needs. The shock of an expanded production of asparagus, mushrooms, and pineapples in Taiwan has been felt around the world. Food production in Mexico has almost tripled, and wheat yields have increased fourfold in the last 20 years. This year's (1969) wheat harvest from 350,000 acres in the Yaqui Valley of Sonora, Mexico, averaged 65 to 70 bushels per acre compared with 10 to 12 bushels 20 years ago. Wheat yields in West Pakistan were 7 million tons in 1967-68, and in 1968-69 will approach 8 million in spite of a dry year. This compares to a previous all-time high of 4.6 million in 1964-65. India harvested an all-time record wheat crop of 20 million tons in 1968-69 compared to 18 in 1967-68, and a previous record of 12.3 tons in 1964-65. West Pakistan has for the first time in history achieved self-sufficiency in food grains —wheat, rice, grain sorghum and maize —and India is near self-sufficiency (11, 12).

The answer is early maturing, photo-periodically insensitive, short, stiff strawed wheat and rice varieties that are disease resistant and respond to fertilizer and irrigation without lodging. The introduction of these widely adapted varieties--creations of the team efforts of scientists, assembled by the Rockefeller and Ford Foundations and directed by Norman E. Borlaug of the International Maize and Wheat Development Center (CIMMYT) in Mexico (47) and Robert F. Chandler, Jr., of the International Rice Research Institute (IRRI) in the Philippines (15)--constitutes the most significant agricultural achievement of the decade.

Can these trends continue until the 21st century? Is the end in sight for further increases in yields per acre? Are we approaching plateaus where no further increases can be realized?

A glance at the data in Table 1, with its comparisons of average and record yields and projections for the year 2000 suggests a great potential ahead. Each year the average, top, and record yields for many commodities move up. The rates of increase are reflected by figures 1, 2, 3, and 4. Factors associated with these remarkable advancements in productivity of the past are inserted for corn (figure 2), potatoes (figure 3) and tomatoes (figure 4). Takeoffs in productivity occurred 35 to 40 years ago for potatoes and corn. Those for rice, wheat, grain sorghum, pearl millet, and soybeans are just beginning.

Topics which follow are related to productivity and yield projections outlined in Table 1 for the 21st century. These will include variety developments and new genetic combinations for disease resistance and for greater photosynthetic capability and yield performance. There will be improved cultural practices, modifications in climate along with the construction of vast agro-industrial complexes, and extensive developments in protected cultivation. Chemicals will be used more effectively to reduce losses from insects, diseases and weeds. Bio-regulants will enhance yields, ripen fruit uniformly, accelerate maturity, and extend the productive life of crops. New technologies will extend the use of processed foods. Harvesting of all fruits and vegetables

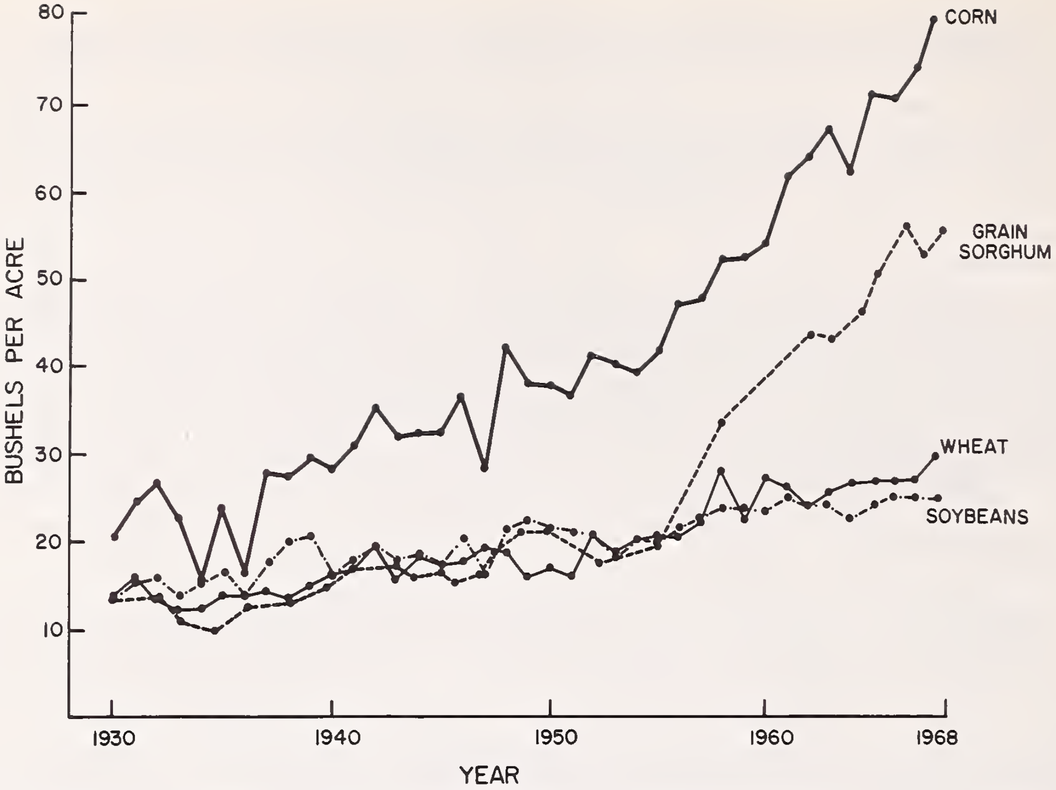


Figure 1. Average yields in the United States since 1930 of corn, grain sorghum, wheat, and soybeans.

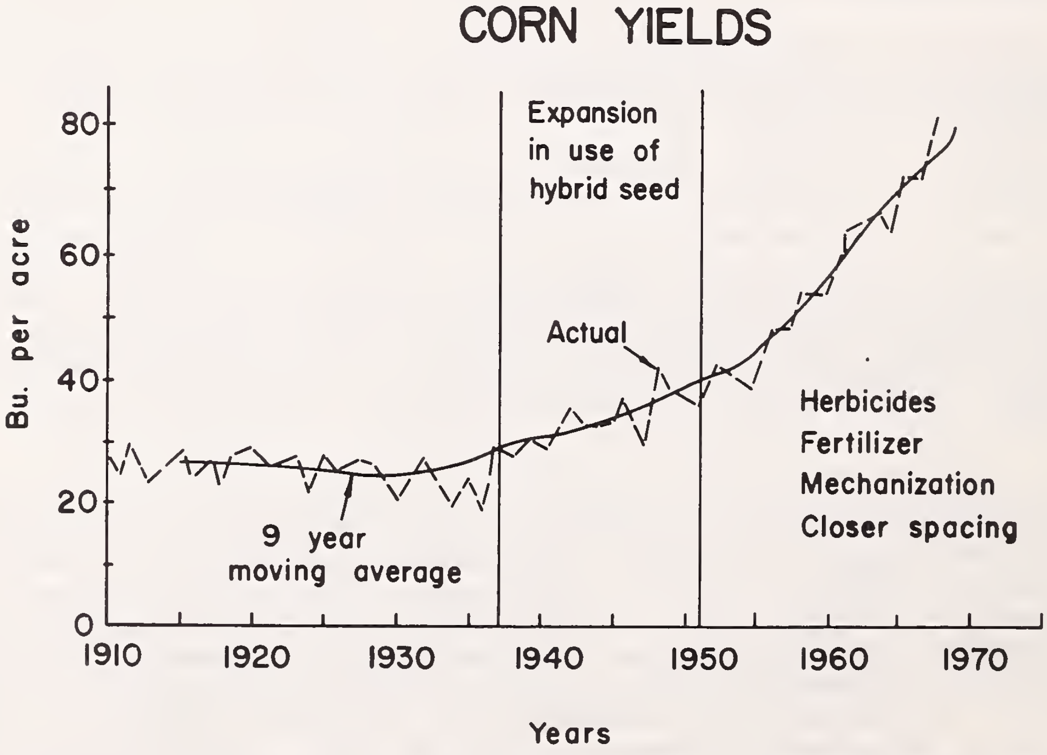


Figure 2. The impact of hybrids, herbicides, fertilizer, mechanization, and closer spacing on corn yields in the United States.

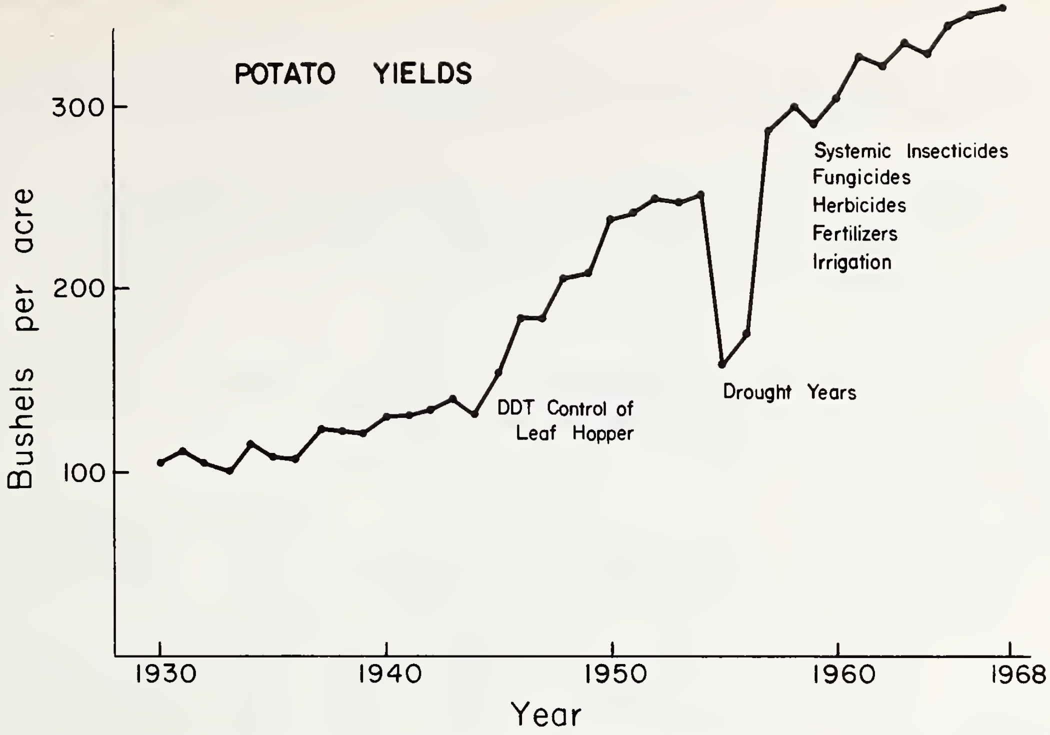


Figure 3. Potato yields in the United States since 1930, and significant factors that contributed to change.

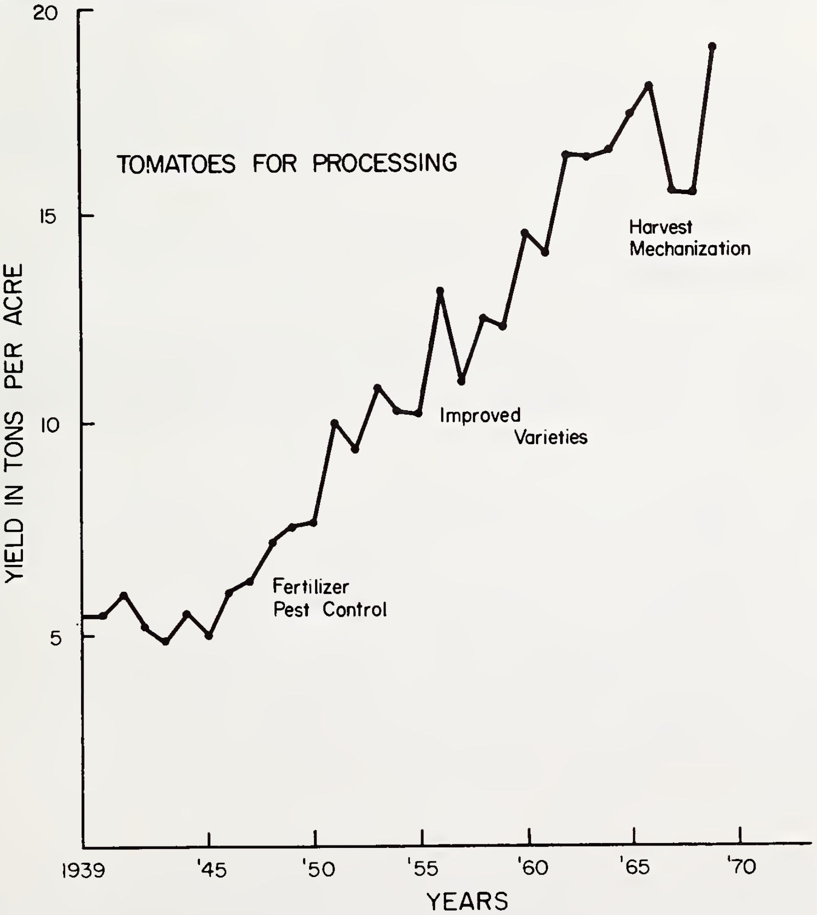


Figure 4. Yields of tomatoes for processing since 1945 and contributing factors.

will be mechanized; and computers, data banks, and automation of operations in crop and livestock production will be commonplace.

In animal agriculture new levels of efficiency in feed utilization will occur with ruminants. High fertility, super-ovulation, and possibly sex control and artificial breeding will be commonplace with all livestock and poultry. Most animal diseases will have been eradicated and great progress achieved in waste utilization.

TABLE I.--Some average, top, and record yields (USA) of crops and other commodities

Crop or commodity		1968			Projected for year 2000		
		Average	Top	Record	Average	Top	Record
Corn	(bu./acre)	79	225	304	200	350	500
Wheat	do	29	125	216	100	200	300
Rice	do	24(World)	150	266	100	250	350
Grain sorghum	do	53	150	320	150	350	500
Oats	do	54	150	296	150	300	400
Barley	do	44	125	212	125	250	350
Soybeans	do	27	80	110	75	150	200
Potatoes	do	355	1,000	1,400	750	1,500	2,000
Alfalfa (tons/acre/year)		2.6	10	16.2	10	15	20
Milk (lb./cow/year) x 1000		9	20	45	18	30	50
Eggs (No./hen/year)		230	275	365	275	350	450

Variety Development

Genetic potentials for new levels in productivity exist for all food crops. As of this writing improved biological efficiencies in production of crops and livestock claim top priority of experiment station directors of the U.S. for projected research needs of the future.

F_1 hybrids have played a dominant role in varietal improvement programs for corn, grain sorghum, sugar beets, pearl millet, and many vegetable crops. More recently barley and wheat have been added (Table II). Millions of dollars have already been expended to make hybrid wheat a reality (17). The first hybrid barley was introduced in 1968 (3). Substantial sums are being invested for hybrids in alfalfa, soybeans and the potato. Hybrids offer the potential of yield increases ranging from 25 to 50 percent, earlier maturity, greater uniformity, and advantages in breeding for disease resistance. It is projected that hybrids will be available and widely used for all agricultural crops produced in the 21st century (Table II).

Triticale, the new synthetic species derived from crossing wheat and rye, shows great promise. Potentially this cereal crop can produce higher yields, is more adaptable, and superior in nutritive value to either of its parents. The current program (4) is to combine selections that are fertile and

TABLE II.--Commercial hybrid varieties in food crops

Early (before 1955)	Recent (since 1955)	Future
Field corn (1921)	Spinach (1961)	Soybeans (1980)
Sweet corn (1933)	Grain sorghum (1955)	Rice (1975)
Tomato (1943)	Pearl millet (1955)	Oats (1975)
Summer squash (1941)	Brussels sprouts (1963)	Rye (1975)
Winter squash (1950)	Cauliflower (1966)	Potato (1980)
Onion (1948)	Alfalfa (1968)	Lettuce (1990)
Pepper (1950)	Barley (1968)	Celery (1975)
Eggplant (1939)	Carrot (1964)	Asparagus (1975)*
Muskmelon (1954)	Broccoli (1961)	Snap beans (1985)
Slicing cucumber (1945)	Red beets (1962)	Field beans (1985)
Pickling cucumbers (1954)	Wheat (1969)	Peas (1985)
Cabbage (1954)		
Sugar beets (1957)		
Watermelon (1949)		

*Faribo F_1 Hybrid introduced in 1953, but very limited commercial plantings.

produce plump kernels with plant types that are insensitive to day length, short-strawed, resistant to lodging, and disease resistant. Expectations are that this will be achieved in 5 to 10 years (figure 5).

New dimensions in plant type are being introduced among the cereal grains of the world (figure 6). The dramatic achievements in productivity thus far witnessed in the Far East, Mexico, and in some parts of the U.S. relate to the pioneering efforts of Dr. Orville Vogel of the USDA at Washington State University and Dr. Norman E. Borlaug (figure 7) of the CIMMYT program in Mexico. A comparable transition has occurred with rice (15). A single genetic factor was introduced into commercial varieties--the short stiff straw that makes the plant resistant to lodging, responsive to fertilizer, and earlier in maturity. Similar advantages exist with rye, barley, triticale, oats, millet, grain sorghum, and corn (figure 8). It is somewhat disturbing that this genetic variant has not been more widely and more rapidly introduced into cereal crops grown in the Midwest and eastern parts of the U.S. Herein is an indictment expressed against the lack of vision among our plant breeders where tall varieties of wheat, oats, rye, and barley predominate. Yields are low and there are still substantial losses each year from lodging. A new world of agricultural technology awaits the use of the short, stiff-strawed, high-yielding small grains (33).

Other desirable characteristics of food crops for the 21st century are summarized below:

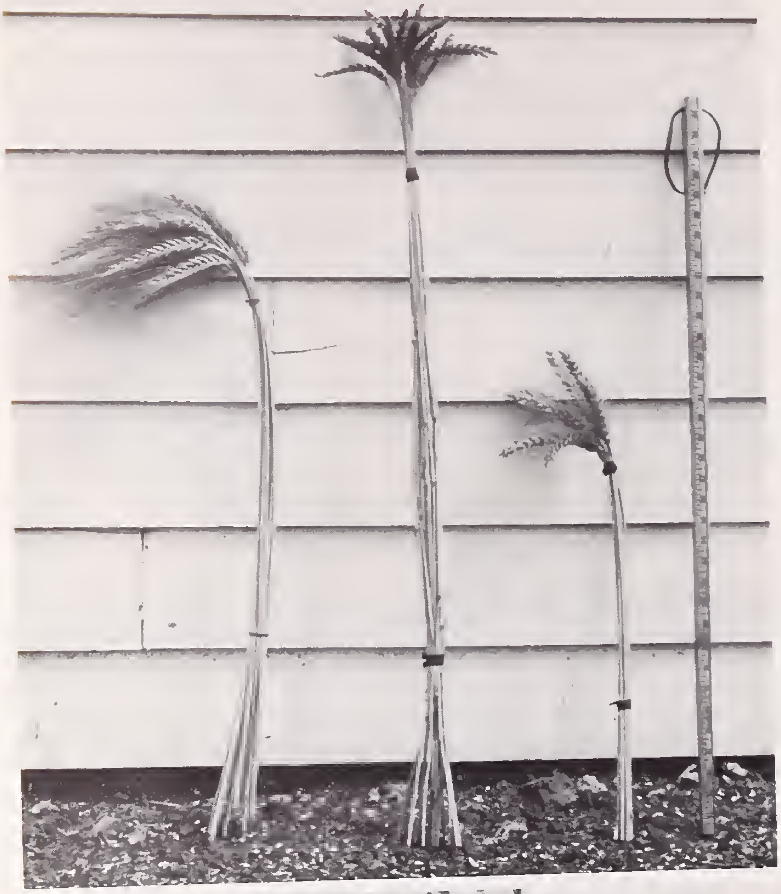
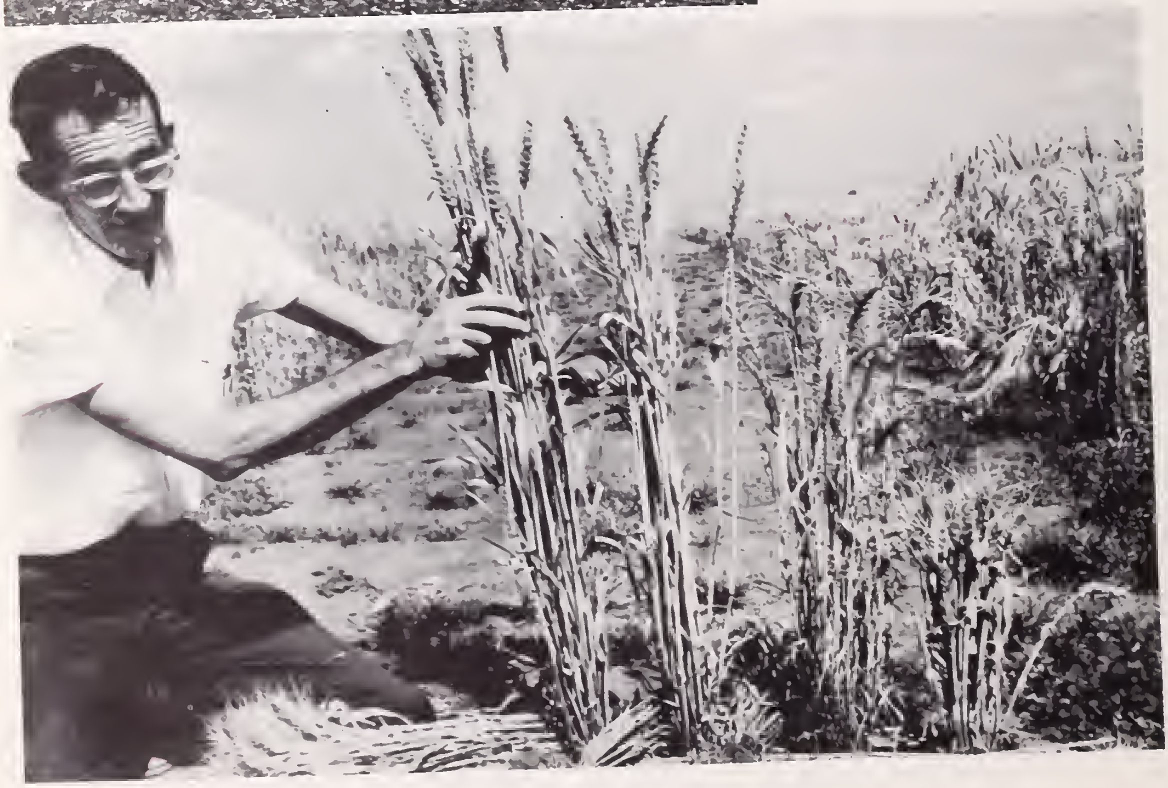


Figure 5. (left) Cereal grains of the present and future. Left to right: short strawed triticales, Genesee wheat, short stiff-strawed wheat, a yardstick to illustrate comparative heights.

Figure 6. (below) Dr. Wm. Roberts of the International Maize and Wheat Development Center (CIMMYT) and dwarf wheat types. Left to right: tall, single, double, and triple dwarfs (Taluca, Mexico, Nov. 1968).



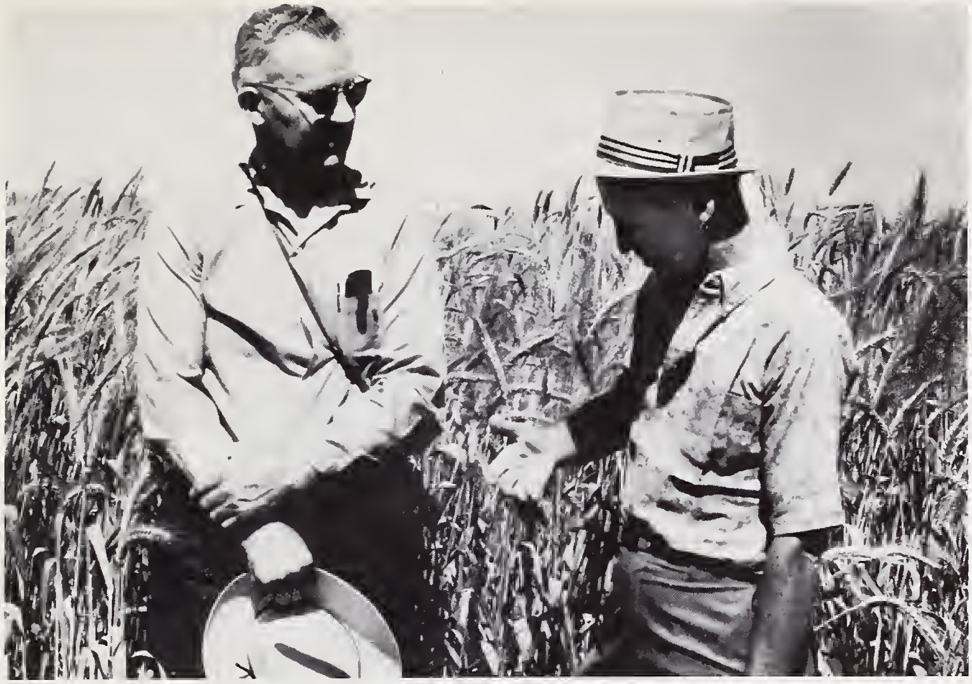


Figure 7. Dr. Orville Vogel (left) and Dr. Norman Borlaug, pioneers in the development of the high yielding, short, stiff-strawed wheat varieties that respond to fertilizer and irrigation, and are resistant to lodging (Ciudad Obregon, Sonora, Mexico, April 1969).

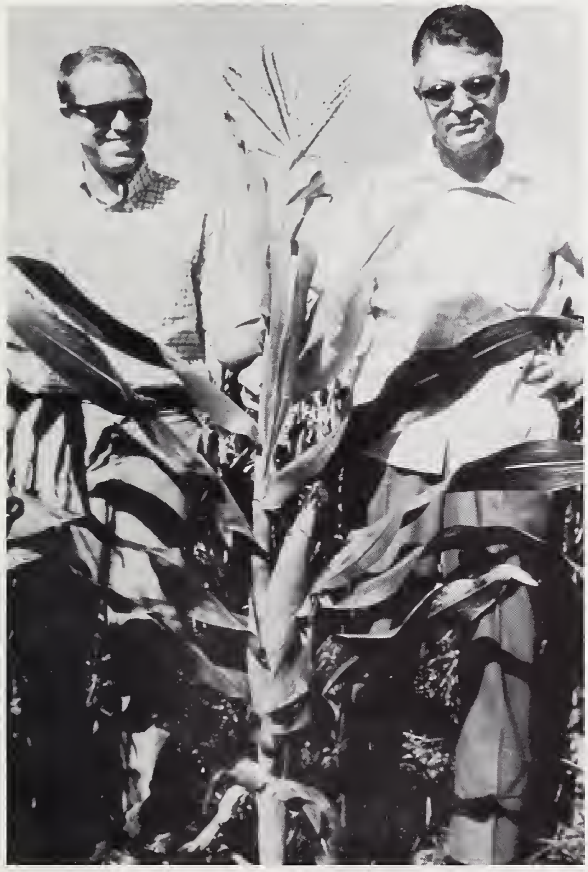


Figure 8. The corn of the future--short statured, single cross hybrids with upright leaves for maximizing photosynthetic capability (Alfred M. Ward & Sons, Akron, Colorado, August 1968).

F_1 hybrids
High protein
Early maturing
Photosynthetic heterosis
Zero or low photorespiration
Photoperiodically day neutral
Highly responsive to fertilizer
Multiple resistance to insects and diseases
Adapted for automation of culture and harvest
Strong upright short stems (stalks) that will not lodge
Plant canopies to retain and fix a maximum of carbon dioxide
Vertical or upright leaf orientation for maximum absorption of sunlight

Many have projected these new shapes for plants of the future (38, 39, 40, 57). They will have superior nutritive value through an improved animo acid distribution and higher protein content exemplified by opaque-2 corn (42), hyproly barley, and some selections of triticale (62). Crop varieties will be early maturing, have vertical upright leaves and branches, be photoperiodically neutral to daylight, be adapted for mechanical harvesting, be responsive to fertilizer including carbon dioxide, and have multiple resistance to diseases. Varieties of potatoes will be developed for specific uses or to correct a production problem. "All-purpose" potatoes will cease to exist.

A parallel to the development of short, stiff-strawed, early-maturing, highly productive grain crops is found in deciduous tree fruits. Dwarfing rootstocks and chemical treatments, separately or in combination, are producing short-statured, low-spreading hedge-row type orchards with several times the number of trees per acre. The trees are designed for once-over mechanical harvesting. A far-out, 21st century concept at Michigan State University is "lilliputian" culture. This project involves several thousand apple or other fruit trees per acre on dwarfing rootstocks which begin to flower and fruit the second year, and will be harvested by specially designed equipment (Figure 9).

New heights in productivity will be achieved during the 21st century by breeding crop varieties for improved photosynthetic capability. This will occur through selection of plants with upright leaf displays having improved light receiving systems, leaf surface characteristics most conductive to CO_2 uptake, and with genetic combinations giving low peroxisome or CO_2-photorespiration (58). Physiologists teamed up with plant breeders and pathologists will select for superior biological efficiency on an individual plant basis.

The great potential in selecting for biological efficiency is emphasized by vast differences that exist inherently among species in apparent or net photosynthesis (28) and crop varieties of the same species (19, 30). Particularly noteworthy are the reports of Zelitch (74) and Tolbert and Yamazaki (58) on differences in peroxisome or CO_2-photorespiration. Heickel (24) observed a 3-fold range in net photosynthesis among 27 varieties of corn. Photorespiration in corn is almost non-existent; light saturation exceeds that of full sunlight, and corn now produces more total digestible nutrients per acre per year than any other major crop in America. Recent studies by Yosida show that differences in photosynthetic CO_2 fixation among rice varieties range from 35 to 60 mg CO_2/dm^2 of leaf surface and that new rice varieties may equal or surpass corn in the

Tropics in photosynthetic capability.* Differences among forages are equally striking (30). Soybeans differ by 100 percent among 36 varieties (18). Total differences in biological efficiencies can be realized only under variable light intensities and concentrations of CO_2.

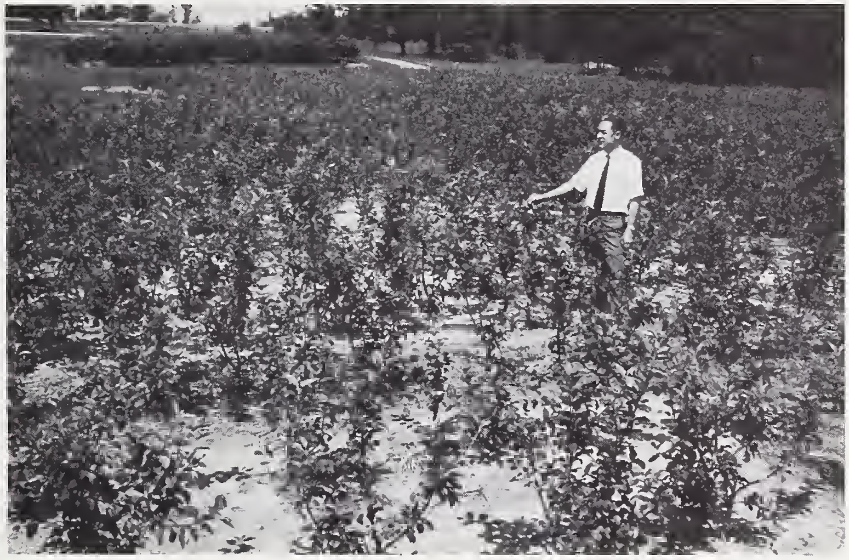


Figure 9. "Lilliputian" culture of fruit trees. Early fruiting apple "orchards" of the future, which will be harvested mechanically, may consist of several thousand trees per acre on dwarfing rootstocks (Horticultural research plots, Michigan State University, July 1969).

Cultural Practices

The use of new super-star crop varieties is usually accompanied by improved cultural practices. Some of them are itemized below:

High plant density
Equidistant planting
Climate modification
Weed free environments
Multiple or relay cropping
Zero tillage and cultivation
Controlled release fertilizer
Foliar application of fertilizer
Complete harvest mechanization of fruits and vegetables
Agro-industrial complexes (food factories) in the desert
Soil moisture control through asphalt barriers and irrigation
Extensive use of low cost anhydrous ammonia as a nitrogen fertilizer
Extensive use of protected cultivation and carbon dioxide fertilization
Undiluted aerial applications of fertilizers, pesticides, and biologically active chemicals

Higher plant populations per acre and narrower rows are an inevitable consequence of the development of short, stiff-strawed (stalked) upright leafed varieties of the cereal grains, corn, grain sorghum, soybeans, field beans, and the highly determinant strains of tomatoes, snap beans, peas, cucumbers, and melons now designed for mechanical harvest (57). Cropping patterns will be changed to accommodate high yielding varieties.

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*Personal communication with Dr. S. Yosida, International Rice Research Institute, Los Banos, Phillipines.

The most efficient plant spacing design is equidistant. As the 21st century approaches, planting and harvesting equipment will be redesigned to accommodate the new system. Weed-free environments will be commonplace, leaving behind the necessity for row spacing and cultivation (figure 10).

Control of soil moisture will be manifest in the widespread use of thin (1/8-inch thickness) asphalt underlayers (figure 11) to retain water (23). This practice will bring into productivity millions of acres of land in droughty or semi-droughty areas of the earth now of little value because of their failure to retain sufficient water for crop production. Extensive field work and yield tests have now been conducted on sand soils in Michigan, Wisconsin, Minnesota, Delaware, Florida, and Arizona. Evidence is conclusive that striking increases in yields of high-return crops are feasible (23). Water requirements for rice and sugar cane production on Taiwan have also been drastically reduced. Increased returns per acre are now well documented.

An example of changing cultural practices and their input for increasing potato yields is detailed in figure 3. Higher-density plantings; irrigation (figure 12); chemical weed, insect, and disease control; and higher fertility levels have all contributed to a remarkable sequence of yield increases.

Concomitant with the development of short, stiff-strawed crop varieties that are insensitive to day length, responsive to fertilizers, and early maturing is a new concept in crop productivity. The potential is great for the Far East, and the Tropics, as well as for temperate-zone agriculture. It is known as relay or multiple cropping (figure 13). Food production can be multiplied by a factor of 2 to 4 (10). This practice, coupled with new high-yielding varieties, can in favorable locations during the 21st century increase food production 4- to 16-fold should the need arise. For temperate-zone-agriculture during seasons of the year when temperatures permit, crops should be planted early enough and at sufficient density that a layer of green leaves is formed as early as possible between the soil and the sun. This is especially important for corn, grain sorghum, soybeans, sugar beets, potatoes, and other crops normally planted in rows.

Fertilizer usage for crops will undergo dramatic change. For many years production capacity in the U.S. has exceeded the demand (43). Agro-industrial complexes under construction, and yet to be built (41), will widen the gap. Nevertheless, world fertilizer consumption has increased from 3.5 million tons in 1920 to 9.6 in 1947, to 40 million in 1965. Projected for 1970 is over 60 million tons and 113 million for 1980. Fertilizer usage in India has increased 12-fold in the last ten years and has tripled in the past two years (26).

The production potential of the new high-yielding wheat, rice, corn, and grain sorghum varieties cannot be realized without additional inputs of water and fertilizer--particularly nitrogen. Irrigation imposes a greater demand for fertilizer nutrients (61). Yields have to be high for irrigation to be profitable. Furthermore, irrigation provides a convenient and economical means of fertilizing crops through foliar sprays and starter solutions. All 14 mineral nutrients required by crop plants can be produced in water-soluble forms as fertilizer. Liquid fertilizer formulations will replace the dry.

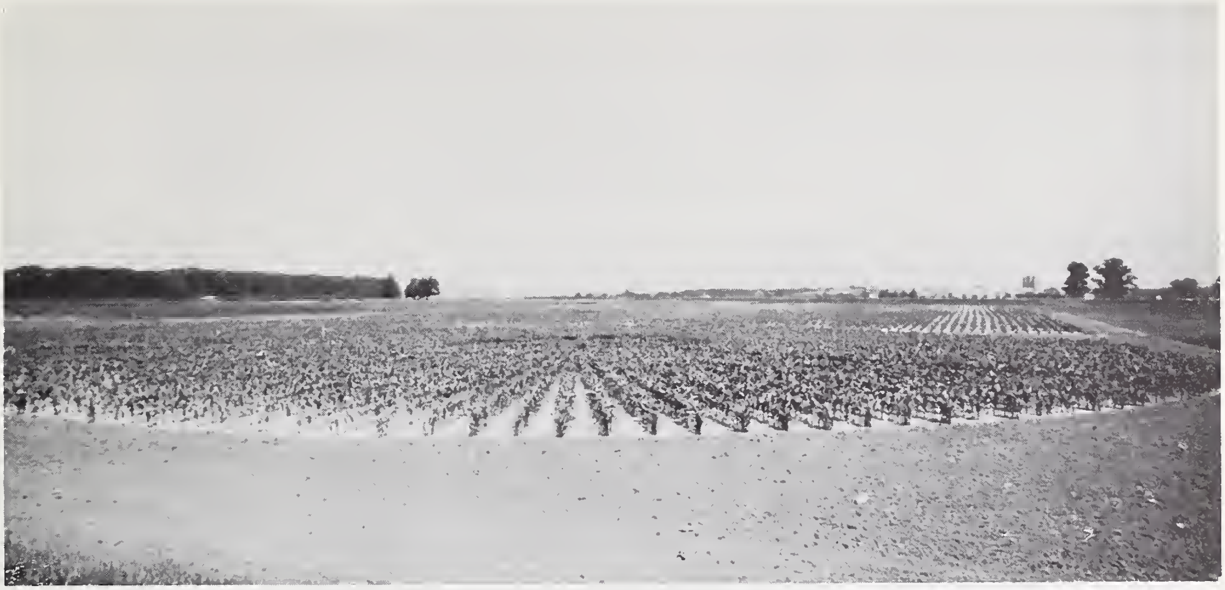

Figure 10. The corn wheel, an experimental design to evaluate the effects of spacing, plant density, variety, and a weed free environment on yields and productivity (Crop and Soil Science research plots, Michigan State University, July 1969).

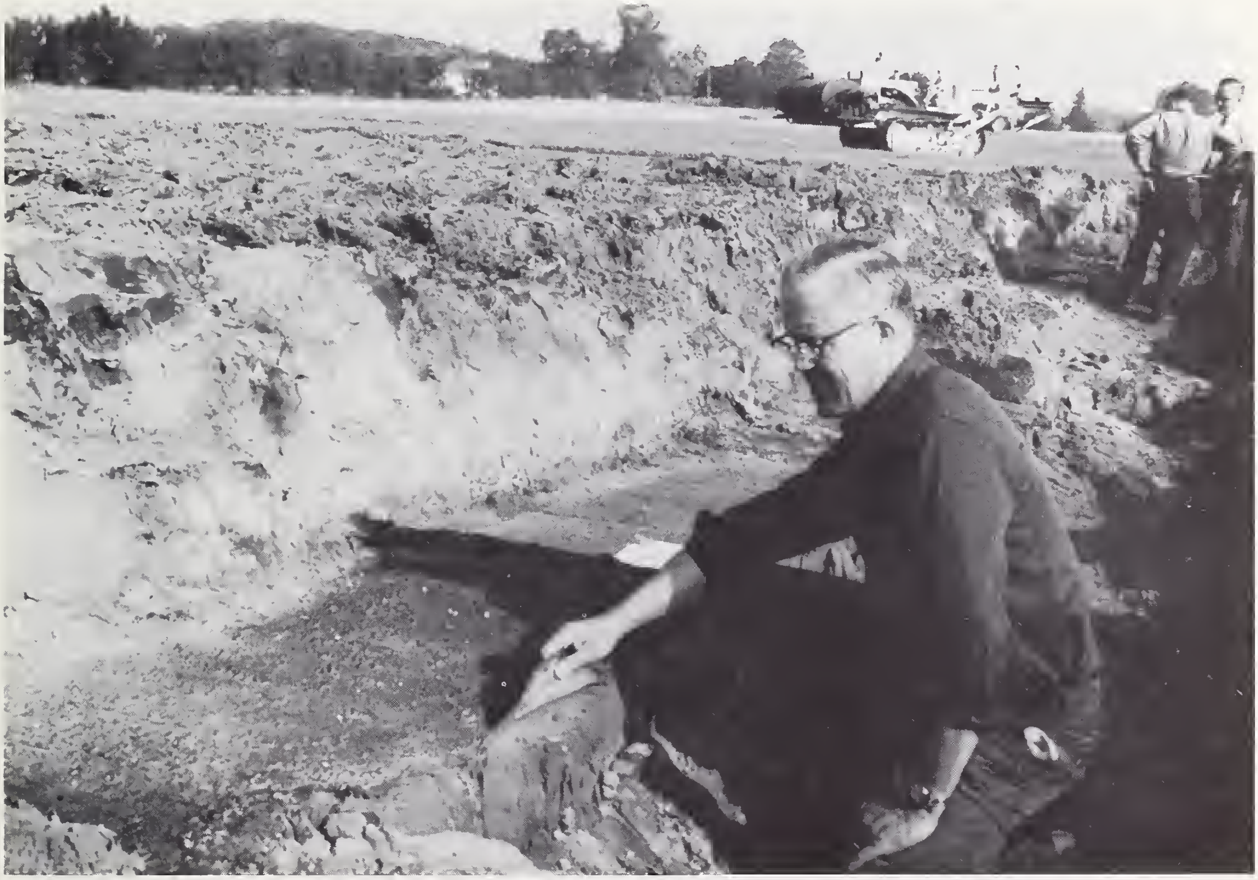

Figure 11. Dr. C. M. Hansen, Agricultural Engineer, Michigan State University, displays the asphalt barrier 1/8" thick which reduces water loss in sand soils and greatly increases their productivity.

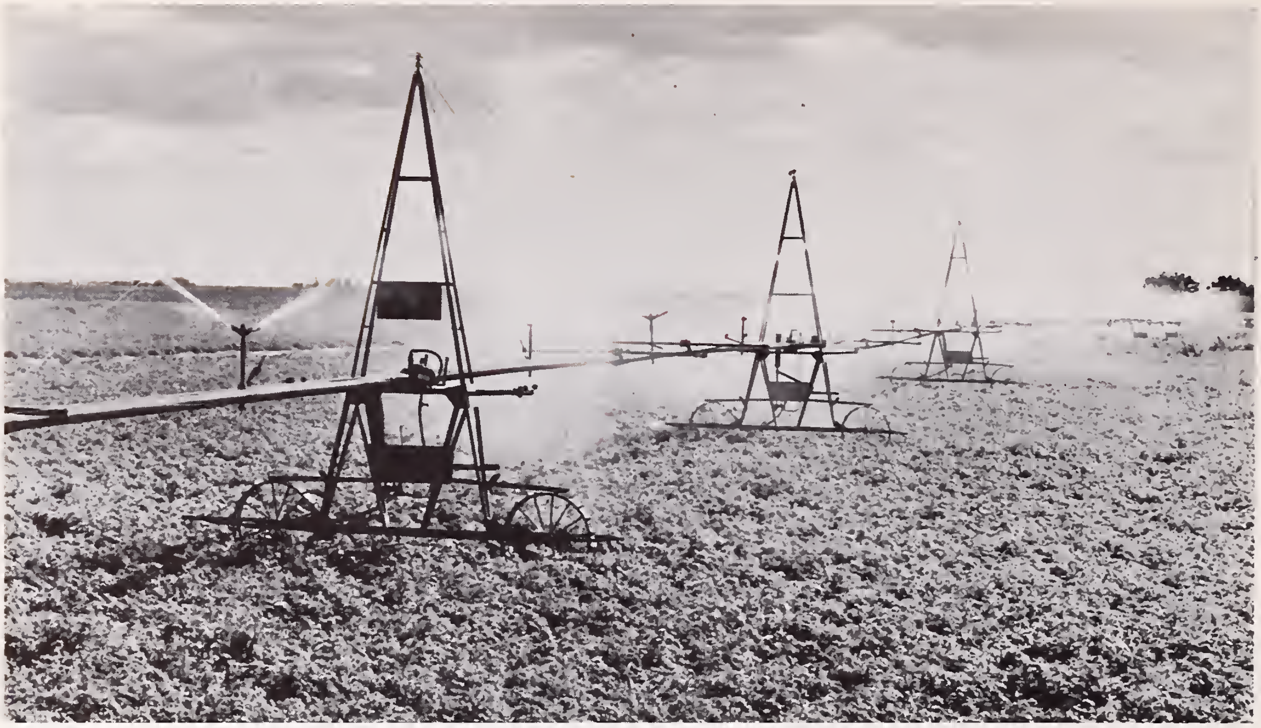

Figure 12. Simultaneous irrigation and fertilization of potatoes with self-propelled sprinkler systems.

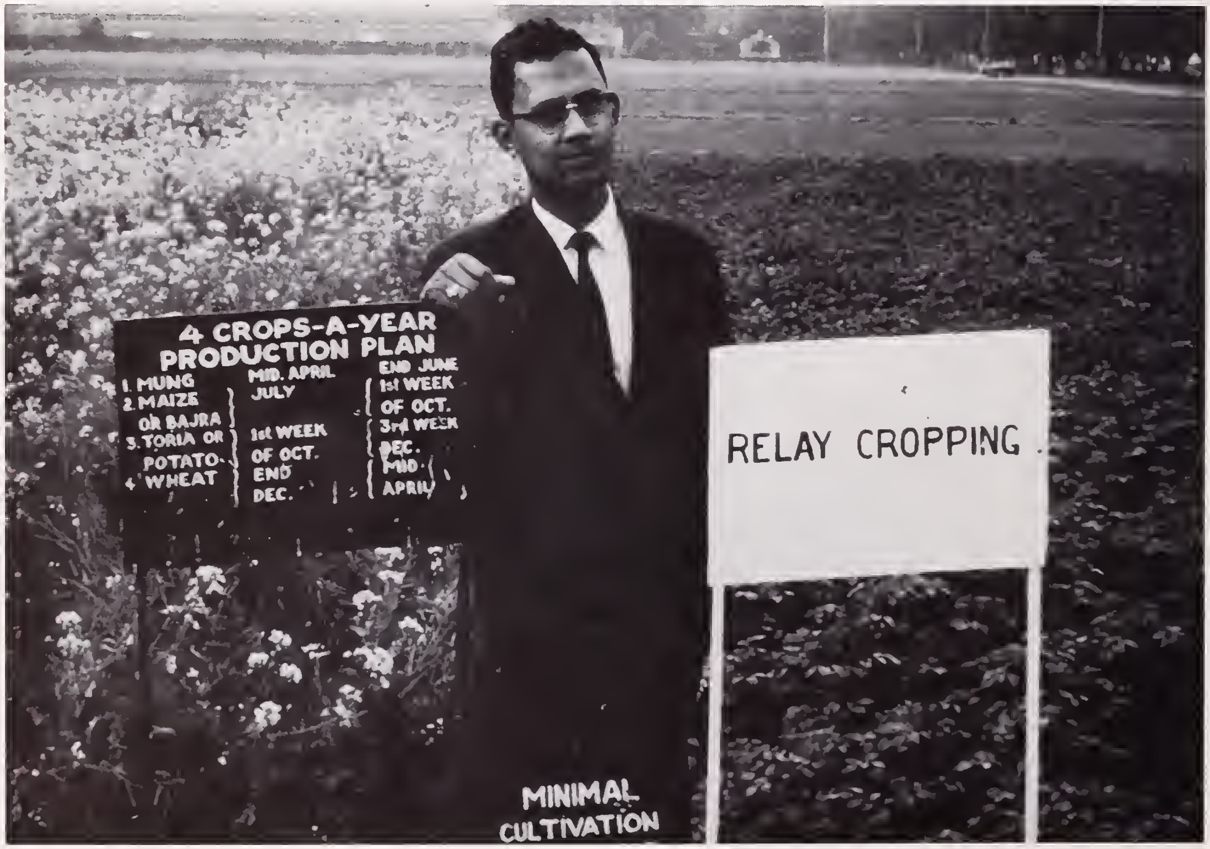

Figure 13. Multiple or relay cropping shows great promise for increasing food production in the Far East and the Tropics (Dr. Rajat De, Agronomist Indian Agricultural Research Institute, New Delhi, December 1967).

Fertilizer nutrients in the 21st century will be used in greater quantity but less indiscriminately. Timing and dosage will be carefully regulated as prescription-type applications. Residues from run-off and sedimentation which are enriching our lakes and streams will be reduced to a minimum. Nutrient sprays, as undiluted formulations, applied to the foliage by aircraft or metered into irrigation systems (figure 11) will be a standard practice for such crops as potatoes, corn, soybeans, field beans, sugar beets, and most all fruits and vegetables (66). Slow-release fertilizers achieved by encapsulation or coating of the nutrients will be used for soil treatment.

The most far-reaching development in fertilizer usage and technology for the 21st century will be the reduction in cost, and the greatly expanded use of anhydrous ammonia (82 percent N) as a nitrogen source. Anhydrous ammonia is now being produced for $18/ton on the Gulf Coast. Through a vast pipeline system now under construction, and already functioning part way up the Mississippi River, this material will be available for $30 to $40/ton (1-1/2 to 2¢/lb.). The expectation is that the productivity of many crops, particularly forage grasses, heretofore not fertilized for economic reasons will now increase substantially.

Protected Cultivation

Fourteen percent of the world's cropped lands, produces 25 percent or more of the world's agricultural crops (73). It is estimated by the year 2000 that there will be twice the present 370 million acres under irrigation. Much of this acreage will be in potatoes. In the desert areas of the earth, where high temperatures and light intensities prevail, irrigation offers the advantages of year around land use, conditions more favorable for insect and disease control, and the timing of water applications. The production potentials are the greatest on earth because of high intensity and continuous sunlight and high temperatures.

Irrigation, the most widely used practice in protected cultivation is increasingly important for frost and weed control. Overhead sprinkler irrigation systems now offer frost protection for 20,000 acres of high-value crops in Michigan. Evaporative cooling by irrigating with overhead sprinklers relieves the stress on plants induced by high daytime summer temperatures (60). Air and soil temperatures may be lowered by as much as 18 to 22 degrees F., respectively. Uniform, rapid, and early emergence of seedlings is encouraged, and as indicated earlier, water is a convenient vehicle for the economical application of fertilizer to a growing crop.

The adverse effects of low temperatures at the beginning and end of growing seasons will be overcome by solid-set heating systems installed in orchards and gardens. They will be powered by cheap electricity or atomic energy. It is projected that by the year 2000 we may heat or cool our fields and crops as readily as we now irrigate them.

Worldwide land areas for crops now under glass, fiberglass, plastic, or rigid polyvinyl chloride (PVC) is conservatively estimated as well in excess of 100,000 acres. The increase is over 10 percent per year. Some of the most productive land acres on earth are those in greenhouses. Yields of tomatoes have exceeded 120 tons/acre/year. Continuous cropping is possible even in temperate areas. Costs of greenhouse construction will be less in the future and production with high quality and dependability will increase.

Food factories in the desert as components of agro-industrial complexes will be created (16, 41). A prototype now exists near Puerto Penasco, Sonora, Mexico. Carl N. Hodges (29) and associates of the Environmental Research Laboratory, University of Arizona, Tucson, with the cooperation of the University of Sonora, and the Rockefeller Foundation, have an integrated system that provides electrical power, water, and fresh food for desert-coast areas. Inflated 12-mil. plastic greenhouses (figure 14) have been built at a cost of 15 to 20 cents per square foot. Food crops (18 have now been grown) are isolated from the harsh surrounding desert climate (34). They are maintained at near 100 percent relative humidity. Water requirements for plant growth are thus reduced to 1 to 10 percent of normal. The positive pressure within provides an environment free of weeds, insects, and disease. Waste heat from the diesel-operated generators of electricity is used for desalination of sea water and for heating of the greenhouses in the winter. Sea water is used for cooling during the summer. Carbon dioxide as a waste product of fuel combustion is introduced into the greenhouses for enhancing plant growth.

One of the most fascinating aspects of the inflated plastic houses is that during winter they also serve as desalination units for seawater. The condensate on the inside from a double greenhouse unit--two houses 23 ft. by 100 ft.--is 1500 gallons per day. Fruiting tomato plants in these same houses require no more than 500 gallons per day. This leaves a positive accumulation of 1,000 gallons per day of fresh water above that required for plant growth. This condensate is collected in a trough at the base of the plastic sidewalls, and stored for summer use, since there is little, if any, condensate in summertime. A contract has now been issued for construction of the first large scale-commercial installation (10 acres) in the Arabian Gulf Shaikdom of Abu Dhabi about 500 miles southeast of Kuwait using the Puerto Penasco unit as a prototype. Such food factions in the desert should be commonplace by the year 2000.

Another important dimension relating to protected cultivation, crop production in greenhouses, and food factories in the desert is the potential for control of the gaseous composition of the atmosphere. The enhancement of crop productivity by enrichment with carbon dioxide from the normal of about 300 to 1000 p.p.m. is well documented (65, 71, 72). All plant-growing structures should now be constructed with the capability for CO_2 enrichment. While yields of all food crops are increased, and in a remarkable manner, by CO_2 enrichment of the atmosphere, the No. 1 food crop in the world--rice--appears to be most responsive of all (51). The yield of rough rice was equivalent to 18.9 metric tons per hectare with CO_2 at 2400 p.p.m. Extrapolation of the data indicated further increases at CO_2 levels above 2400 p.p.m. For other plants, there is also an increase in growth and productivity if the oxygen level is reduced as the carbon dioxide concentration is increased (6, 7).

Crop Protection

It has been estimated that annual losses in agriculture from weeds,

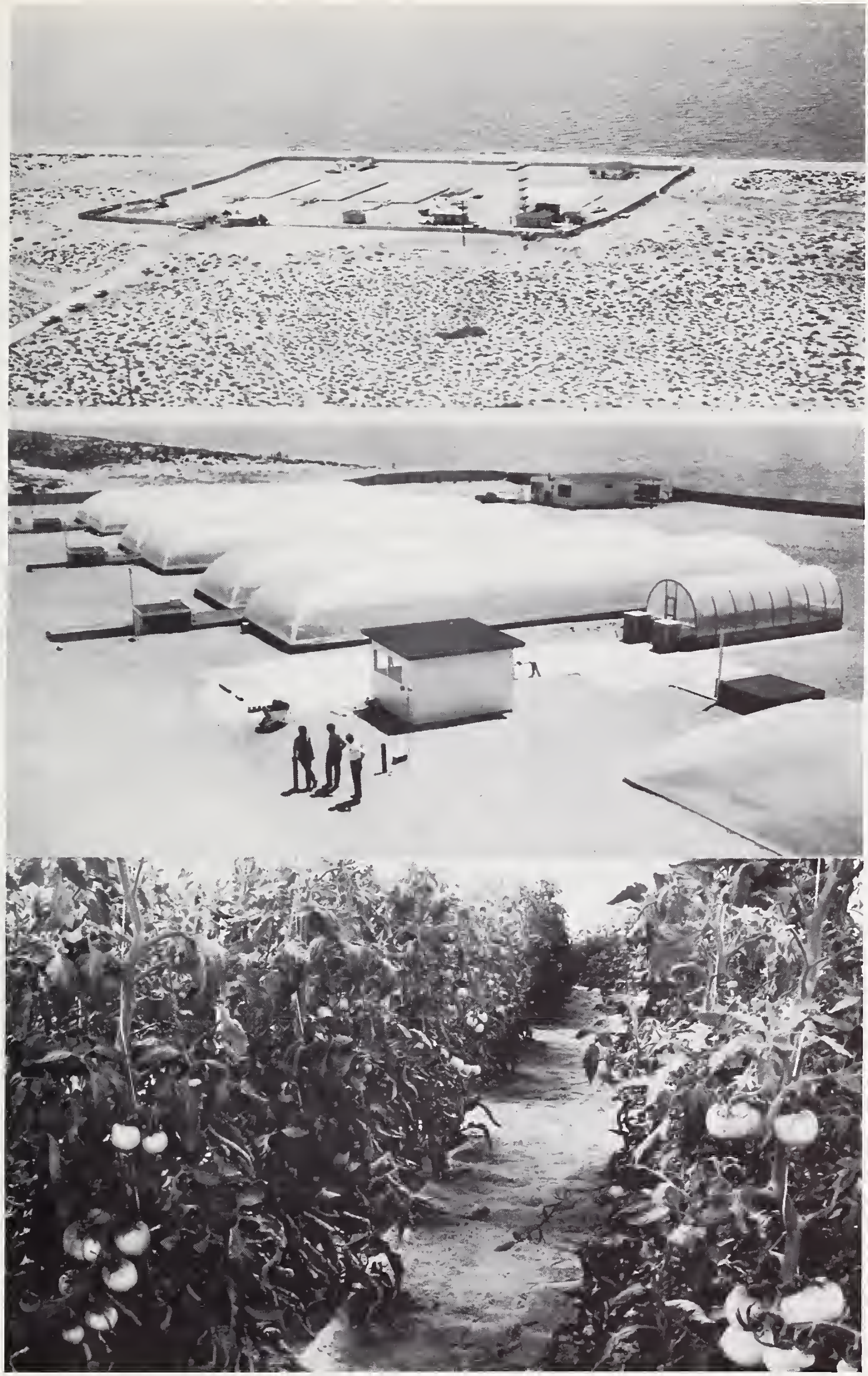

Figure 14. A food factory in the desert at Puerto Peñasco on the Gulf of California, Sonora, Mexico. Top, the entire complex of greenhouses, desalination tower and electrical generators; center, the inflated greenhouses of 12 mil plastic; bottom, tomato production inside the greenhouses, April 1969.

insects, and plant diseases aggregate over $12 billion (59). This does not include the ravages of livestock and poultry diseases which will be dealt with later. Weeds, insects, and plant diseases result in a 20 percent reduction in crop production in the U.S. This is the equivalent of 75 million acres of crops still being used to feed insects, weeds, and plant pathogenes. Great challenges and potential achievements are ahead for all aspects of pest control. Some exciting developments are just now in progress.

Weed-free environments, as a consequence of treating with chemicals having a variety of exotic names, are a near reality. Prescription weed control is already possible with orchards, vineyards, and nurseries, utilizing Simazine, Sinbar, and Paraquat. Atrazine, Lasso, Ramrod and Sutan give good results in corn. Eptam, Randox, and Treflan are recommended for field beans and Pyramin and TCA for sugar beets. Potatoes respond to Eptam and Lorox, and Sinbar shows remarkable results on mint.

The most striking all-time record of insect control on a major agricultural crop was achieved by DDT on potatoes. Use of this one chemical doubled yields in less than five years (figure 3)*. This was followed in the early 1960's by soil treatments of the systemic insecticides Thimet and Disyston, which have further enhanced yields of this crop. Systemics, valuable because they give a constant rather than the fluctuating controls from spray programs, and because residues are almost nonexistent, will characterize pesticide usage in the 21st century. Aphids and beetles on beans are effectively controlled by foliage sprays of Systox and soil-applied Thimet. Lindane has given 150 percent increase in yield of rice by control of the stemborer (56), and Baygon, though not yet cleared for use, is highly effective as a seed treatment for control of the cereal leaf beetle.

Other fascinating developments with tremendous possibilities for field applications for the 21st century are the sex attractants and the insect juvenile hormone that have been discovered and identified (52, 53). The latter is non-specific and effective at a level of one gram per acre. More exciting still is that certain insecticidal synergists, now used and commercially available possess a high order of juvenile hormone activity and show species specificity (9).

Plant disease control offers challenges and opportunities equal to those for insects. Systemic fungicides are finding their first application. Difolaton and Benlate are effective agents for control of apple scab and potato blights. For apple scab single-spray applications in April offer good protection throughout the growing season. Benlate shows promise in control of the fungus responsible for the Dutch elm disease. It will be a great achievement, soon to be realized, when systemic fungicides can be effectively applied to the seed of annuals and as a foliage spray to perennials. It is projected, with the advent of systemic insecticides and fungicides, that spraying for insect and disease control will disappear well before the advent of the 21st century.

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*The author is indebted to Dr. Ray L. Janes, professor of Entomology, Michigan State University, for his valuable assistance in this section.

Control of bacterial diseases of plants offers the greatest opportunity since little progress has thus far been made. Among the most destructive plant pathogenes, you will recognize angular leaf spot and bacterial wilt of cucurbits; crown gall of stone fruits; common, halo, and fuscous blights of beans; Stewart's wilt of corn; fireblight of apples and pears; bacterial spot of peaches, nectarines, plums and apricots; bacterial canker of sweet cherries; bacterial canker and wilt of tomatoes; bacterial spot on peppers; and bacterial stem and leaf blights of rice, to name a few. All bacterial diseases of plants are caused by representatives of only six genera, and most arise from only two (Xanthomonas and Pseudomonas). Control of bacterial diseases will reside in the development of resistant varieties, and once resistance is established it should be terminal, unlike resistance to fungal diseases.*

Bio-regulants

Plant growth substances (auxins, gibberellins, kinins, abscissins, inhibitors) have made great contributions in regulation of flowering and fruiting and in prolonging the storage life of many horticultural crops and commodities (45, 68). Gibberellin is perhaps the most widely used and proved growth substance in horticulture. It has revolutionized the production and marketing of Thompson seedless grapes in the past 12 years (68). No grapes go to market, for table use, without treatment for increased size and quality. Treatment of wheat seedlings with CCC, introduced in 1959, is the chemical equivalent of the genetically regulated short stiff straw. One to two lb./acre are effective and all varieties of wheat respond (31). The chemical is used extensively in western Europe. Maleic hydrazide, discovered 20 years ago, prevents sprouting and prolongs the storage life of onions and potatoes (68).

Superstar regulators, Regim-8, Alar, and Ethrel have recently emerged. They are indicative of things to come. Regim-8 (2,3,5-triiodobenzoic acid) is the first plant-growth substance to be widely used for increasing yields of a major food crop in the U.S. Approximately 10,000 acres of northern grown soybeans for seed were treated in 1968. Regim-8 has now been cleared for use on all soybeans, and large commercial acreages will be sprayed in 1969. Treated plants develop a triangular profile and leaves point upward, allowing better penetration of light to lower leaves. The beans mature earlier, yields are enhanced by 3 to 20 bushels per acre, and there is less lodging.

Alar (N,N-dimethylaminosuccinamic acid) is the wonder chemical of horticulture (2). It advances the flowering and fruiting of apples by several years. Properly used, it can be the chemical equivalent of the dwarfing rootstock. Alar accelerates color development and maturity in sweet cherries, increases the tolerance of peaches to winter cold, greatly promotes fruit set in grapes, and stops preharvest drop, enhances coloration, and prolongs storage life in apples.

Ethrel (2-chloroethylphosphonic acid) or liquid ethylene opens new frontiers in growth regulation (1, 45). The more important effects include the induction of uniform flowering and fruit maturity in pineapples, the inhibition of male flower formation and the stimulation of female flowers in cucurbits (figure 15), acceleration of ripening and concentrated fruit maturity in tomatoes, and the promotion of fruit abscission in apples, grapes, tomatoes, cherries, and citrus. Other effects are yield increases in cereals, soybeans, beets, potatoes and peas, and beans. Increased tillering and a reduction in lodging has been noted for wheat, rice, and peas.

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*The author is appreciative of suggestions from Drs. William B. Drew, Allan Jones, and Fred Saettler, of the Department of Botany and Plant Pathology, Michigan State University.

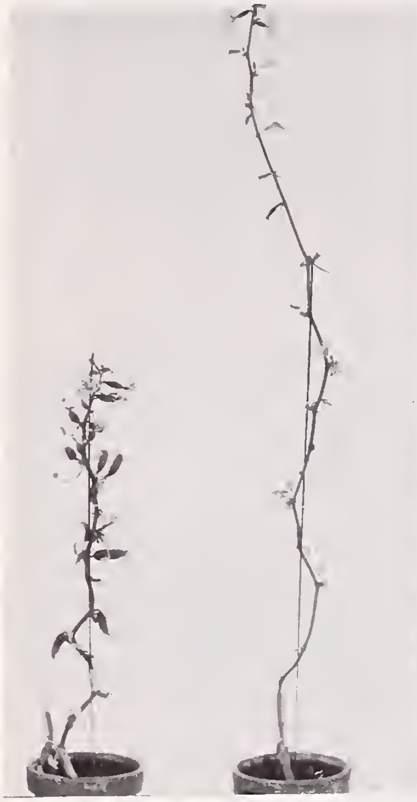

Figure 15. Control of flower sex expression in cucumber with "Ethrel" (2-chloroethylphosphonic acid). Left, completely female plant induced by foliar sprays of 250 p.p.m. Ethrel at the first and third leaf stages; right, control. (Photograph courtesy of Dr. S. Shannon, New York State Agricultural Experiment Station, Geneva, New York.)

Simazine, terbacil and other herbicides have induced a remarkable increase in protein yields per acre for some conventional food crops (49, 50). Field applications of 1/4 to 1/2 pound per acre in Michigan and Costa Rica increased both the yield and protein content of beans, peas, rye grass, and alfalfa from 10 to 52 percent. This is a new dimension for increasing the total protein and food productivity in developing nations especially where fertilizer supplies are still inadequate. More recently, oat and wheat seeds with a higher protein content as a result of previous chemical treatment yielded significantly more grain. The protein content of the seeds, subsequent growth, and yields were directly correlated (55).

The multiple effects outlined above for these few plant growth substances and herbicides are suggestive of unpredictable yet significant, breakthroughs yet to come in modifying plant behavior and in enhancing the productivity of crops in the 21st century.

Emphasis on Food Processing

New processed products will be developed and varieties will be created to meet the specifications of these new items. Flavor components will be identified and adjusted with flexibility. Proteins from different sources (plant and animal) and of comparable nutritive value will be interchanged, as fats now are, in the design of prescription-formulated processed foods (22). Microbial control without heat and high-temperature short-time (HTST) processing will become realities.

Agriculture in the 21st century will be noted for its source of new materials heretofore not utilized and now discarded as byproducts. New synthetic foods beyond our present vision will appear. These will meet the specific dietary demands of the old and young, the aged and infirm.

These are some of the projections in food processing (54). Many commodities--apples, tomatoes, potatoes, onions, turkey--now purchased both in fresh and processed forms will be predominantly or totally processed by the year 2000 if present trends continue. These are illustrated for turkeys (figure 16), onions (figure 17), potatoes (figure 18), and tomatoes and apples (figure 19). The remarkable increases in the processed product for onions and potatoes reflect the development of new products and the improvement in technologies for making the old (figures 17 and 18).

Some of the most spectacular developments in the processing industry have been with potatoes. Forty-one percent (95.6 million cwt.) of the crop is processed and this excludes potato starch and flour (4 percent). Potato chips comprise 34 percent of the processed volume but they are decreasing by 10-12 percent/year. Frozen products are increasing most rapidly, and at present utilize 41 percent of the processed volume. They also constitute over 40 percent of the total frozen vegetable pack. This makes the potato by far the largest freshly frozen commodity. Approximately 70 percent are french fries. These were first introduced on a commercial scale in 1945. Dehydrated potatoes represent 20 percent of the processed volume. The quantity doubled between 1964 and 1965 (83,000 to 167,000 short tons). The large volume began in 1956 with the advent of instant potato products. The per-capita consumption of processed potatoes has increased remarkably. It was 2 pounds in 1940, 23 in 1956, 36 in 1964, and at present has reached an all-time high of 47 pounds/person. It is projected that fresh potatoes will be marketed only for baking, and that within ten years 75-80 percent of all potatoes will be processed.

Factors contributing heavily to the ever-increasing volume of processed products include new product development, improved technologies in processing, an increasing demand for convenience in kitchen (partially or fully prepared) foods, mechanized harvest of fruits and vegetables, and varietal changes in crops to adapt them to mechanized harvest and handling.

Automation, Mechanization, and Computers

Problems relating to the lack, uncertainties, and cost of labor currently constitute the greatest single area of concern in agriculture. There is an urgency to automate and mechanize. Answers reside in many areas. For dairying, America's No. 1 agricultural enterprise, 55 percent of the labor requirement is in milking cows. This will be automated. It is projected that the present milking rate of 42 to 50 cows per man can be increased to 120 cows by (a) facilitating movement of cows into stalls in the parlor, (b) automatic washing, (c) automatic milk quality testing, and (d) automatic removal of the milking units. The final goal, perhaps by the year 2000, will be the automatic placement of the milking machines on the cow. There will be increased mechanization and programmed feeding, handling, and waste removal for all livestock and poultry. Space requirements will be less and productivity greater for laying hens (67).

Twenty years ago the production and harvest of cereal crops, forages, and sugar beets were well mechanized and progress was being made in cotton. Harvest mechanization of perishable fruits and vegetables that must be handled gently was then virtually nonexistent (5,36).

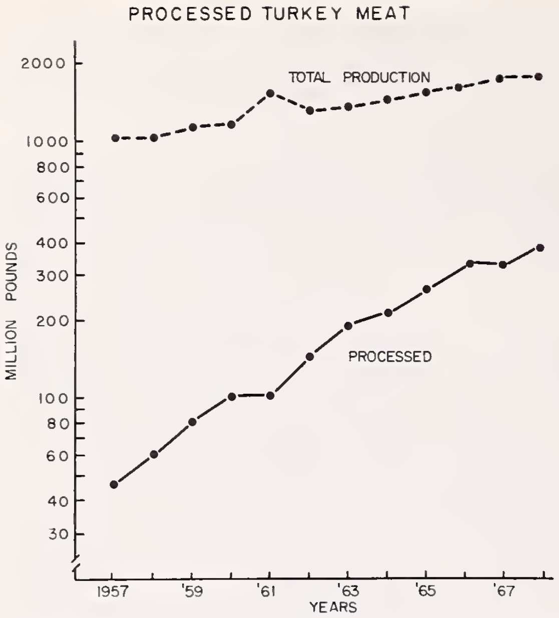

Figure 16. Processed turkey meat has increased 10-fold in the past 10 years, and now constitutes an important part of the total supply. (The assistance of Dr. L. E. Dawson, Professor of Food Science, Michigan State University, in the preparation of this chart is gratefully acknowledged).

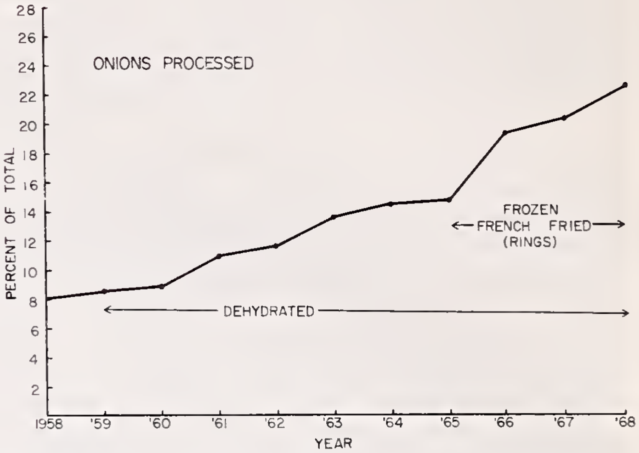

Figure 17. Percentage or total onions processed from 1958 to 1968. Note the impact of dehydration and frozen french fried rings. (Data courtesy of Dr. Smith Greig, Department of Agricultural Economics, Michigan State University.)

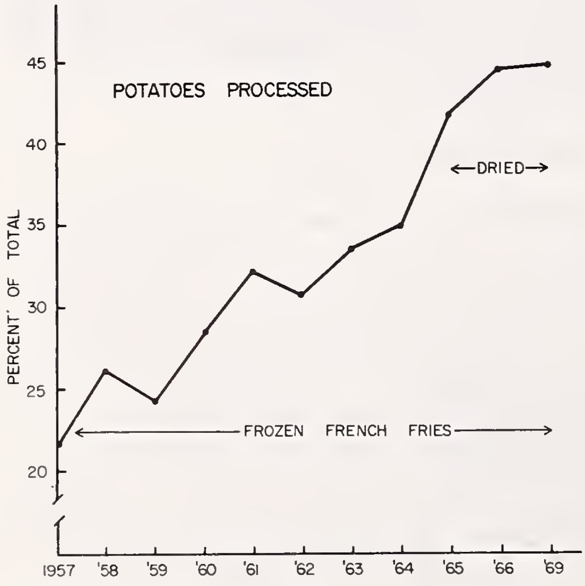

Figure 18. The percentage of potatoes processed has increased from 22 percent in 1957 to 45 percent in 1968-69. Note the impact of frozen french fries and more recently (since 1965) the dried product. (The assistance of Dr. C. L. Bedford, Professor of Food Science, Michigan State University, in the preparation of this chart is gratefully acknowledged).

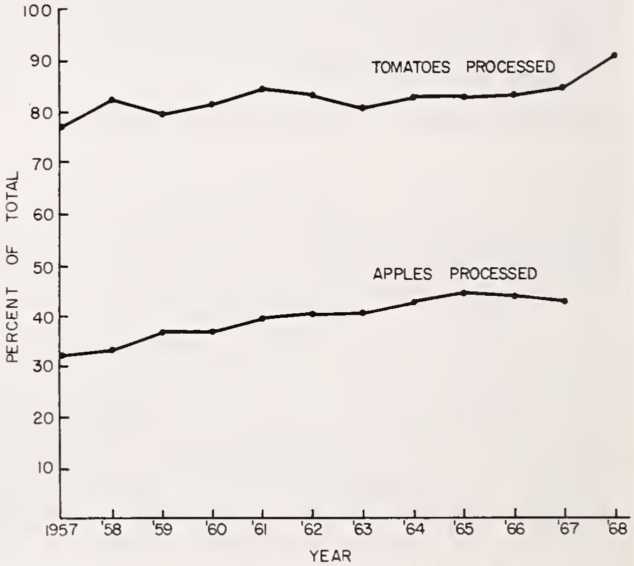

Figure 19. A steady increase since 1957 has marked the percentages of tomatoes and apples that are processed.

All this is changing and with remarkable rapidity. Since 1962, in a period of seven years or less, nearly complete harvest mechanization has been achieved for processing tomatoes in California and blueberries (figure 20) and red tart cherries in Michigan (Table III). Such progress has not been matched in our history or in any other major area. Projections are that for the 21st century all fruits and vegetables to be grown for processing or for fresh market will be harvested mechanically. All orchards should now be planted, and the trees trained, with the intent of mechanized removal of the fruit. We will grow only those for which production, harvest, and handling operations are fully mechanical. The great challenge ahead is for citrus. Harvest and handling costs have increased three-fold in the past four years, yet mechanical harvesting is still nonexistent.

TABLE III.--Progress in mechanical harvesting of fruits and vegetables*

Year	Pickling cucumbers (Michigan only)	Processing tomatoes (California only)	Blueberries	Red tart cherries
		Percent harvested mechanically		
1962			5	1
1963		2	10	2
1964		5	25	5
1965	2	24	40	10
1966	10	75	65	35
1967	20	80	85	50
1968	36	90	90	70
1969	50	95	95	80
2000 (Projected)	100	100	100	100

*Data derived in part from "Fruit and Vegetable Harvest Mechanization and Technological Implications," B. F. Cargill and G. E. Rossmiller, Editors, Rural Manpower Center, Michigan State University, E. Lansing, 838 pp., 1969 (14).

The advantages of mechanical harvesting for fruits and vegetables are inescapable. Costs are reduced to 1/3 to 1/2 of hand harvest. The product is harvested at optimal maturity. Yields are higher. The uncertainties of labor are eliminated. Reduced harvest costs will encourage new product development. Production will be possible in high-cost labor areas. Products will be more acceptable, and eventually of higher quality, if hand harvesting is eliminated.

Mechanized harvesting imposes many challenges in variety development for fruits and vegetables. Maturity and ripening must be uniform. The harvest must be concentrated. Ripe fruit must hold on the vine or tree for an extended period and then be easily separated from it. The fruit must also be of great firmness. Varieties must have high fruit:vine or fruit:leaf ratios.

The history of potato harvesters is one of continual progress. Recent innovations include the vacuum-lift attachment to separate tubers and rocks (figure 21). The great need is to reduce bruising in the handling and harvest operations.

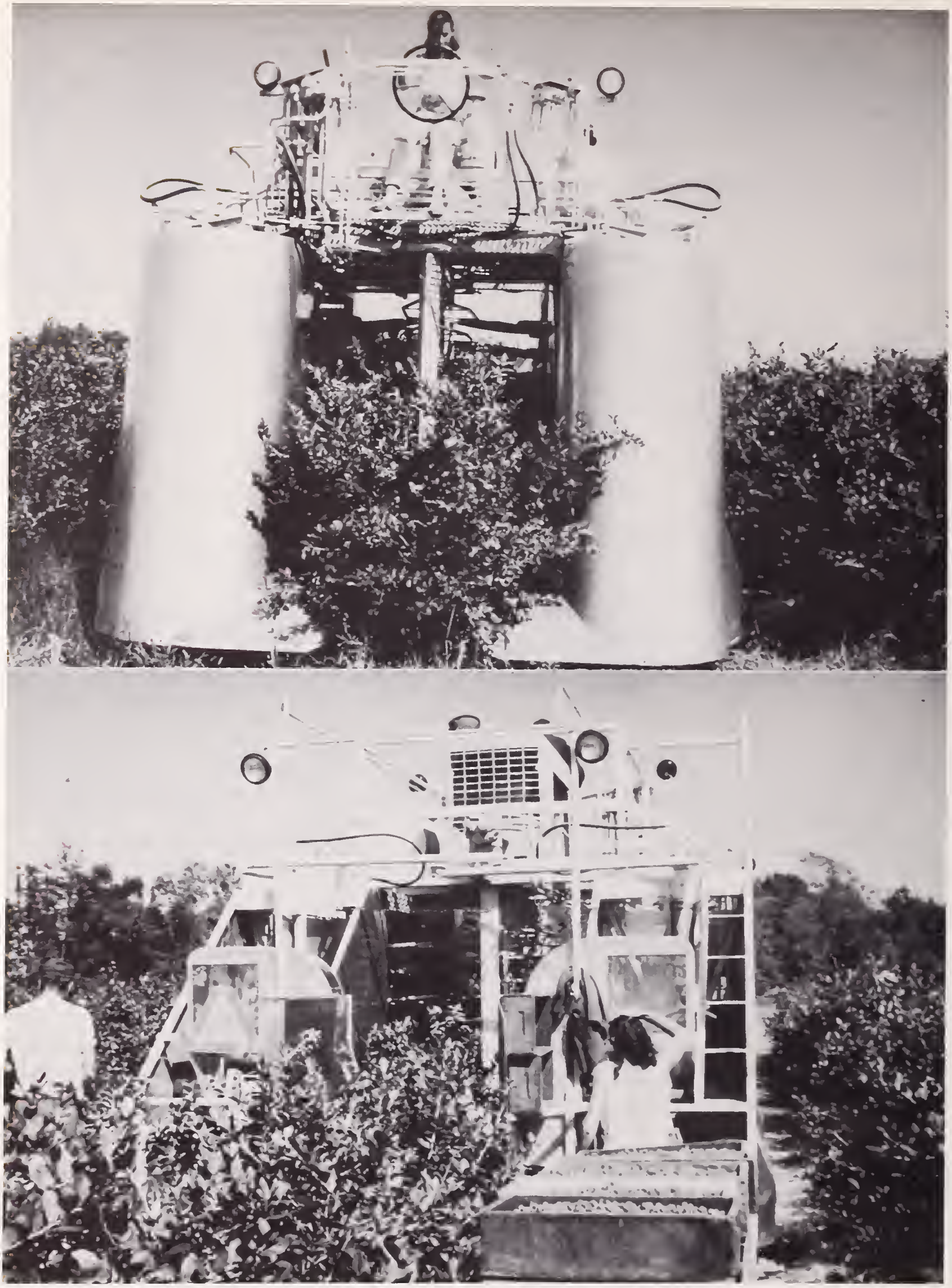

Figure 20. Harvesting of blueberries is now 95 percent mechanized in Michigan. Three people and one machine harvest one ton of blueberries per hour and replace 200 hand pickers. Top, front view; bottom, rear view.

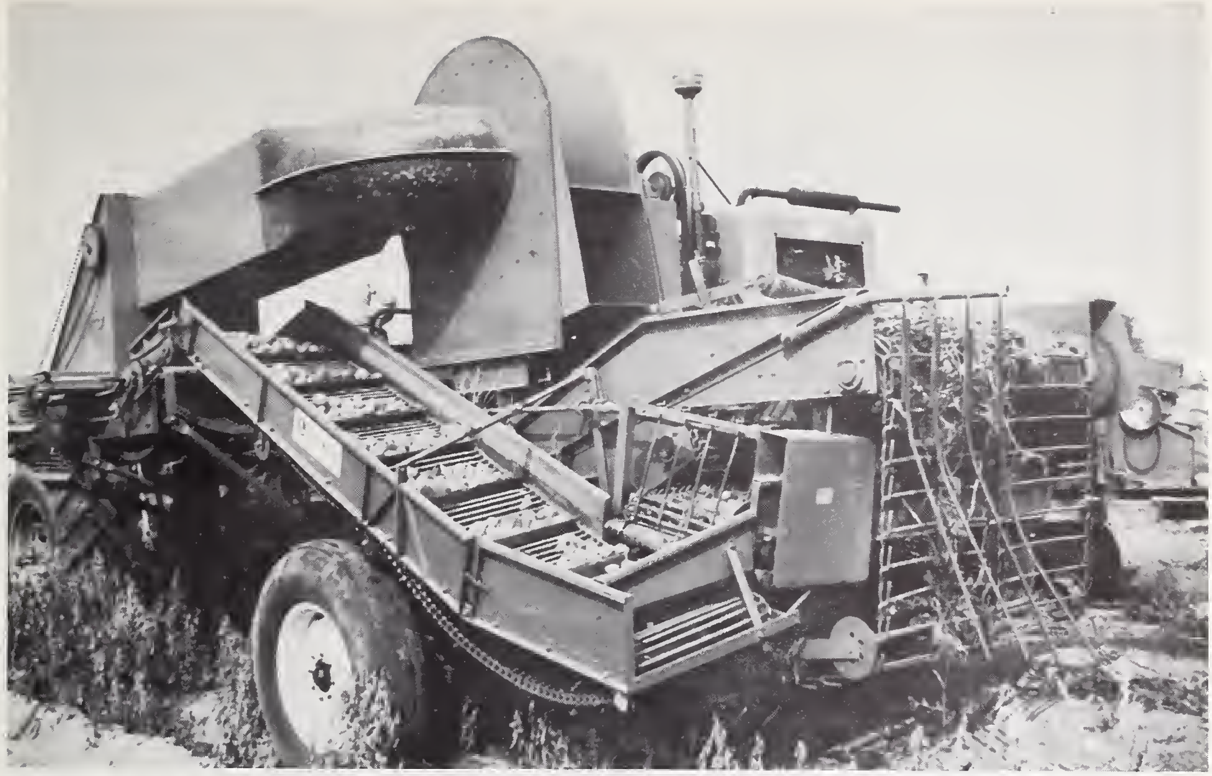

Figure 21. A modern potato harvester with vacuum lift for separating potatoes from rocks.

Computers, data banks, and remote sensing will become a part of the vocabulary of commercial agriculture. Storage and retrieval of information and knowledge with instant communication media to obtain facts are foreseen for the 21st century. The earth, including all crops, livestock and wildlife, will be mapped through multi-spectral photography from conventional aircraft and satellites. Crop surveys and crop reporting will be updated daily and methods revolutionized. Outbreaks of plant diseases, insects and weed infestations will be predicted and water stress and drought conditions localized long before they can be identified from ground observations.

Ruminant Nutrition

The livestock numbers of the world (1.87 billion cattle, 1.03 billion sheep, 0.51 billion hogs) about equal the human population. Projected increases of livestock and men are comparable. Farm animals, however, have the ability to convert forage and grasses and, in some instances, nonprotein nitrogen (63) into protein for human consumption. Furthermore, about half of the plant material that results from cereal production is in the form of waste, or straw. This is not suitable for human consumption, but can be fed to livestock (32). Over half the total land area of the U.S.--about a billion acres--produces forage, and of the total area in farms, 62 percent, or about 700 million acres, is classified as forage-producing land. Thus, animal agriculture is important the world over and especially in the United States. As an example, it is projected by the year 2000, if present trends in beef consumption continue, that we will have 44 million on feed and 128 million other cattle--twice the present number (30).

Comparative efficiencies in the conversion of plant to food protein are listed in Table IV (13). The efficiency of the dairy cow in milk production is

TABLE IV. Efficiency conversion of plant to food protein (after Byerly (13))

Animal product	Protein efficiency	Protein efficiency with urea
	Percent	Percent
Cow, milk	47	70
Hen, egg	36	--
Chicken, broiler	23	--
Pig, pork	16	--
Steer, beef	7	17

obvious, and remarkable increases in efficiency are evident when urea is added both for dairy and beef animals. The greatest challenge is for increased efficiency in feed conversion for all livestock and poultry (Table IV). This is especially evident for beef cattle where it is the lowest. Virtanen (63) has declared that protein is not essential in a milk cow's diet. This opens the door for milk production in every country of the world. Nonprotein nitrogen sources (urea, biuret, ammonia salts) can be used to meet the protein requirements of ruminant livestock. Already about 125,000 metric tons of urea, as an inexpensive protein substitute, are now fed annually to over half the cattle in the U.S. Further research will reveal even greater possibilities in feeding ruminants even larger amounts of cheap nitrogen for conversion to protein. Biuret, a nonprotein nitrogen source has just been cleared for use. Unlike urea, the ammonium from biuret is released slowly in the rumen, making it safer and more efficiently utilized. Very recent studies with the most economical of all protein sources, anhydrous ammonia, suggest that it can also be efficiently and safely utilized when added to corn silage fed to ruminants (25).

Records for dairy cows show that milk production has increased by 3.4 percent per year during the past ten years (figure 22). No genetic or management plateaus in productivity have been reached, nor is it likely that we will face them before the 21st century (37, 46).

Heterosis (CrossBreeding), Fertility Control, and Artificial Breeding

Heterosis has contributed to greater efficiency in feed utilization, more uniformity, and maternal ability (13). , Cross-breeding within a species of farm animals (beef cattle, dairy cows, hogs, sheep, poultry) has improved the rate of gain and other performance traits. Cattle breeders prefer the Hereford-Angus cross. We may be approaching genetic plateaus with chickens, but not with livestock. Cross-breeding has given 5 to 20 percent increases in rates of gain over the best parental breed (64). This technique will be widely practiced in the 21st century.

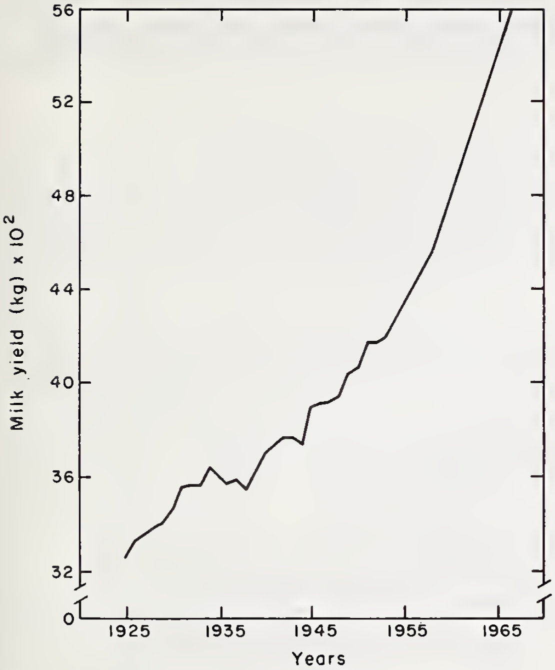

Figure 22. Milk production of cows on the DHIA program in the USA from 1925 to 1968.

Great progress will come in breeding beef animals and hogs for more lean and less fat. Barrows have already been designed that cut over 50 percent ham and loin, and yield up to nine square inches of loin eye.

Low reproductive rates are the most important single factor in limiting cattle production efficiency. For beef animals in the United States, only 75 to 80 percent of the cows mated raise calves to weaning (64). In The Netherlands and Denmark, it is 90 percent; that for developing countries only 30 to 50 percent. Birth control for cattle has been achieved through the use of progestational-type hormones, and their use will become standardized. They help synchronize estrus and allow for more efficient artificial insemination. The discovery of how to produce superovulation (21) will find application in promoting multiple births in livestock.

Artificial breeding will become standard for all livestock and poultry. In the United States it is now 100 percent for turkeys and 50 percent for dairy cows. Artificial insemination (AI) from 1963 to 1967 increased by about 10 percent. Leading European countries are Denmark (98 percent), Hungary (94 percent), Czechoslovakia (88 percent), Finland (74 percent), France (67 percent), Great Britain (65 percent), USSR (61 percent). Other countries are Israel (95 percent), Japan (95 percent), and Canada (19 percent). It is still practically nonexistent for beef cattle and swine (27). Great progress in the successful storage of semen will occur long before the year 2000, and AI will become worldwide for all livestock and poultry.

Animal Disease Control

One of the greatest overriding challenges for contemporary agriculture and the 21st century is a reduction in losses from animal diseases. Losses in animal products from disease alone are 17.5 percent for Europe and North America, and 35 percent for the rest of the world. In Latin America, Africa, and Asia it is much higher than 35 percent (44). This equals or exceeds the combined losses in crops from insects, diseases, and weeds (59). A 50 percent reduction in losses in animal diseases in Africa, Asia, and Latin America would increase supplies of animal protein by 50 percent.

Among the most destructive diseases are rinderpest, contagious bovine pleuropneumonia, foot and mouth disease, African horse sickness, African swine fever, hog cholera, Newcastle disease, fowl plague, and brucellosis.

Recent years have seen a revival of the principle of infectious disease control in livestock and poultry by better sanitation, management, isolation and eradication, and in some instances less dependence on drugs and vaccines. This is true of TGE (transmissible gastro-enteritis) of swine, shipping fever of cattle, and mastitis in dairy animals.

Disease eradication programs are meeting with great success. This was the most effective control for the recent outbreak of foot and mouth disease in Britain. Vermont, Michigan, Wisconsin, North Dakota, Montana, Wyoming, Idaho, Utah, Washington, Oregon, Nevada, and Alaska are now hog cholera free. The goal in the United States is eradication by 1972. California just became (June 1969) the 16th State in the Nation to be certified as a brucellosis-free area. Most animal diseases enumerated above will have been eradicated in the U.S. by the 21st century, and great progress will be evident in other parts of the world.

Animal Waste Utilization and Confinement Housing

Significant changes will occur in these related areas. Space allotted per animal for finishing livestock and for laying hens will progressively decrease (67). Research on utilization of animal byproducts (manures) and those from food processing will gain high priority. Systems for animal waste utilization will involve the soil (figure 23) as a living filter (35). The

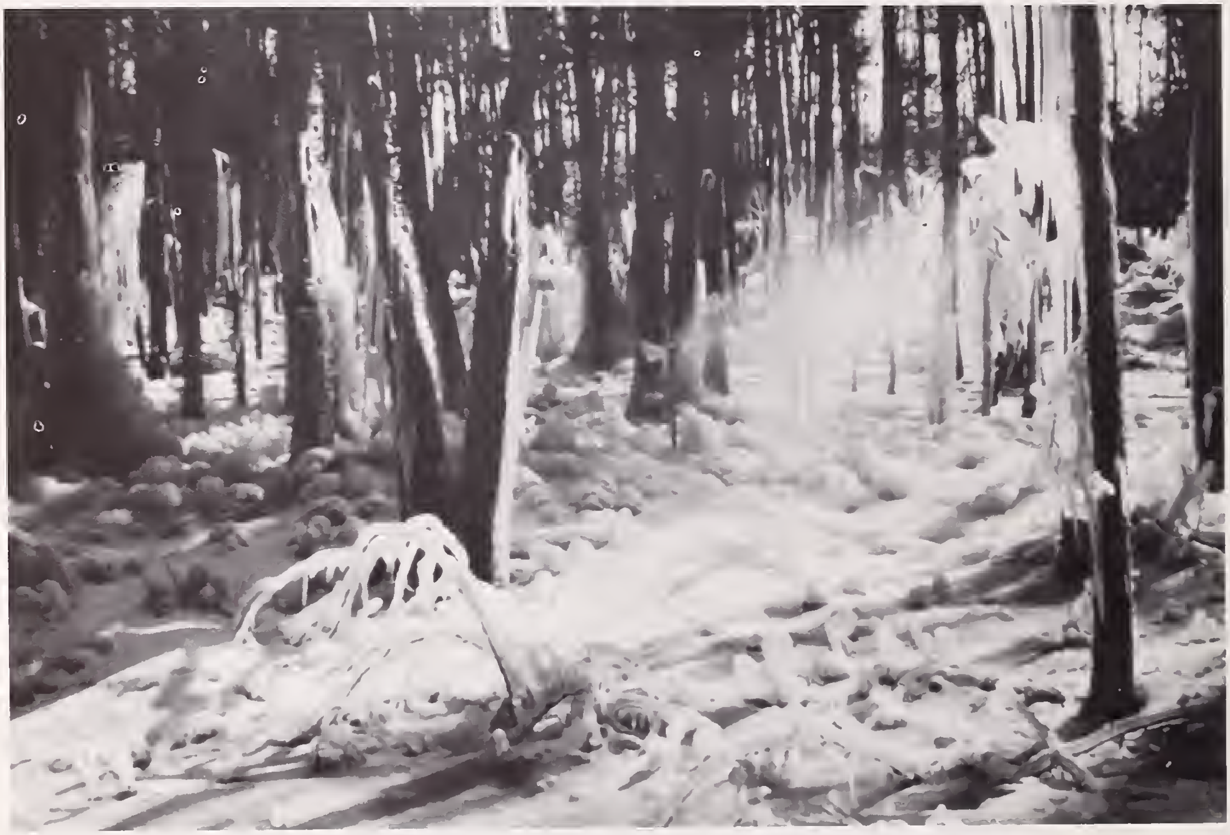

Figure 23. Disposal and utilization of nutrients and reclamation of water in sewage effluent using forest soil as a living filter. (Photographed February 1969 at Pennsylvania State University (35))

intentional inclusion of wastes (feces) in the diet of poultry (20), and possibly for hogs and cattle, will receive attention. Reclaiming wastes, either through conventional agricultural crop and forest tree production, or aquatic farming of fish and plant life, are other possibilities.

There will be great advancements in climate control for livestock and poultry in confinement housing. The importance of shade, increased air movement, and cool drinking water has been demonstrated. Some dairy farmers have found that milk production is increased 15 to 20 percent in an 85 degrees F. barn if the cow's neck and head are placed in an enclosure cooled to 60 degrees F.

Tomorrow's livestock and poultry will be finished in confinement. Remarkable engineering improvements can be foreseen in automatic feeding devices, air conditioning units, and improved environmental controls. Results will be evidenced in more rapid weight gains, better disease control, and higher feed efficiency (67). The challenges are great and the opportunities unlimited.

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Consumer Dialogue

WHAT DO CONSUMERS THINK ABOUT THE POTATOES AND PREPARED POTATO PRODUCTS NOW AVAILABLE IN FOOD MARKETS?

Moderator: George T. Stachwick
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East Lansing, Michigan 48823

Opening Remarks by Moderator: The consumer dialogue is a relatively new educational tool. It was started after the consumer boycotts and strikes of 1966, following the moderate food price rise of 2 to 2-1/2 percent in 1965 and the sharp increase of almost 6 percent in 1966. Many business interests have held consumer dialogues in the past two years, and a number have been held in Michigan. Dr. R. W. Chase suggested that we stage one on potatoes for this meeting. We are most interested in the outcome, because we have never before done one on a specific commodity.

The first part of our dialogue will be fairly highly structured. This is necessary to ensure a full presentation and discussion of a wide variety of products. We are indebted to our consumer marketing agent in the Grand Rapids area, Ada Shinabarger, who brought half of the women on our panel from Western Michigan, and to Sheila Morley, who brought the other half from the Bay City-Saginaw area.

[The first questions to the panel developed the background information given in Table I. They also disclosed that two of the panelists regularly ate away from home--Mrs. O once a week and Mrs. LA three times a week. All the panelists reported that they shop once a week, except Mrs. SP and Mrs. MA, who shop twice a week.]

MODERATOR: Let's find out something about the shopping habits of our panel. Do you like to shop in one store, or more than one store?

MRS. MA: Two stores.

MODERATOR: What is the reason?

MRS. MA: Better selection.

MODERATOR: Of what particularly?

MRS. MA: Everything in general.

MRS. SI: I usually go to two, and sometimes three, stores.

MODERATOR: What are your reasons for changing around?

MRS. SI: I find some staples cheaper in one store and the meat is better in another store, and perhaps the vegetables are better in still another store, and if I have time I like to shop in at least two stores.

TABLE I.--Background information on consumer panel

Panelist	No. in family		Ages of children	Weekly grocery bill
	16 yr. & over	Under 16 yr.		
Mrs. O	2	3	7,5,3,	$30-35
Mrs. LA	4	2	13,15,18,20	40-55
Mrs. D	5	4	9,11,13,15,19,22,24	60-70
Mrs. SP	4	2	10,13,16,18	50-60*
Mrs. W	5	3	12,14,15,17,20	45
Mrs. K	2	1	9	20-25
Mrs. MO	2	3	5,6,8	20-25
Mrs. LI	4	1	15,17,19	55-60**
Mrs. SI	3	1	15,19	40
Mrs. MA	2	1	18 mos.	25**

*No including most meats.
**Usually others at table besides family.

MODERATOR: So fresh produce does play a part in your selection of at least one of the stores?

MRS. SI: Oh yes, definitely.

MRS. LI: I change around for the same reason. I have two stores, and I don't like the produce at the one where I do most of my shopping. So I go to the other store for my fresh fruits and vegetables.

MRS. MO: Grocery store for staples, meat market for meats, and we have a farmers' market in town where we get our vegetables in the summertime.

MRS. K: I shop two stores, one where they give no stamps and the prices are cheaper, and I like the meat and fresh produce there. And I buy my staples in the other store, where I get stamps.

MRS. W: I shop at two stores. I like one because I know where everything is, but I can get a bargain at the other one, so I go there occasionally.

MRS. SP: I go to two stores. One of them gives stamps and I get things there if the price is the same as at the other store. I don't like the produce at the store where they give stamps.

MRS. D: I shop at a supermarket where we get everything except milk and eggs. I also go to a day-old bread store.

MRS. LA: I watch the papers for the best buys, and I get them if the stores are not so far away that I would use up the savings in gasoline. But I do have one store that I patronize completely, except in the summertime, when I get my fresh fruits and vegetables at the stands in the country.

MRS. O: I go to one store, mostly because of the convenience. I know exactly where things are, and it's much faster when you are familiar with the store. But as soon as the farmers' market opens in the summer, I try to buy my vegetables exclusively there, because they are much fresher.

MODERATOR: I have just one final question. How do you feel about food shopping in today's markets? Are you satisfied and happy with it? Do you enjoy the shopping trip, or is it a burden that you wish someone else would do for you? Mrs. O?

MRS. O: Well, for the first five years I was married, I thought it was fun because it gave me a few minutes away from our toddler. I still enjoy it if I have time. It's time-consuming, something that has to be planned for. If I can plan for it, and I know what my menus are going to be, and what I am shopping for, then I enjoy it. But if I have to go in and fight the crowds and bump the baskets and wrack my brains for what I need, then I don't enjoy it.

MRS. LA: I find I have to wait in line much longer now in these big supermarkets. It takes me over an hour to get the shopping done, and it didn't previously. I don't like the waiting in line a long, long time. They do have the fast lines, but when you buy for a family, you don't get in the fast lanes.

MRS. D: I try to shop when I can go by myself and have enough time. As Mrs. O says, it is time consuming. I usually go first thing in the morning, and I like to buy everything at the same store. I do take advantage of the sales. I buy quite a few things that are on special and freeze or preserve them.

MRS. SP: I really don't mind it. I go once a week when the crowd is not bad and you get a good selection. If you go Monday or Tuesday, everything's gone and the new stuff isn't out yet. If you go Wednesday or Thursday, you are all right.

MRS. W: Well, I really enjoy shopping. It's one time I can get away from the family.

MRS. K: I love shopping. Although we have only one little girl, I do a lot of shopping for large groups. I cook for church groups, etc. I like to shop in the off-peak periods, because I like to look at the quantity you are getting for the price. I compare a little bit.

MRS. MO: I agree with Mrs. K to an extent. I enjoy the challenge represented by the different products, and you can compare prices. And as far as getting through the checkout counter and paying for a small basket of groceries, this I don't enjoy. It seems that each week you walk out with less and less groceries, but you are paying more. This gets a little discouraging.

MRS. LI: I love shopping. I go on Wednesday and I take my mother and my sister, neither one of whom drives. By the time we get done, my car looks like a hauling van or something. I like to try all the new things. Each week I look for something that's new and different, and if any in the family want to know what something new is like, they ask me, because I have usually tried it.

MRS. SI: I really enjoy shopping. It's a pleasure to go out, and I like to compare prices and sizes and brands, and I enjoy trying all the new products, and to me it's quite interesting. I try to figure out how much I can save, and still provide my family with decent meals and a balanced diet, which I feel is quite important.

MRS. MA: I like to shop, but for a small family, there are problems. You don't know whether to buy the 12-ounce can or the 32-ounce can. The prices vary a great deal, and there are so many brand names that you don't know where your money is going.

MODERATOR: Now let's just take a minute to summarize what kind of a panel we have here in the light of our knowledge about Michigan and particularly the representative family unit in Michigan. As I indicated, these 10 women represent families totalling about 50 people. If my short division is right, this averages out to about 5 members per family. This is something more than 1-1/2 members per family size larger than the average size family in Michigan. Also, I note we have only one lady who is very questioning about enjoying shopping in our supermarkets here in Michigan. This is, I think, a little weighted. Usually when we have a panel of 10 people as we have here, we get at least two, and sometimes as many as three, who find food shopping fairly distasteful, or at least a fairly unpleasant experience today, particularly in the large supermarkets which tend to be somewhat impersonal. I think you will note that our panel is one that is very much interested in food, and that means very much interested in your business. I would guess that we will get some fairly pleasurable responses as far as you're concerned about their attitudes towards potatoes and potato products.

Now let's raise some questions with these ladies about their family preferences and utilization habits as far as potatoes are concerned. We will start out by asking: How often do you serve potatoes to your family? Let's start with Mrs. W.

MRS. W: At least once a day, usually twice, and once in a while three times a day. My husband likes pancakes for breakfast and the rest don't, so quite often we have potatoes for breakfast.

MRS. SP: Well, in summer it's a little different. My children love potato salad, and I usually make a big dish of that at least three times a week. But I would say normally we use 15 to 20 pounds of potatoes a week.

MODERATOR: Up to 20 pounds a week. Pretty fair utilization of potatoes. Mrs. K.

MRS. K: We don't use very many potatoes, although I was brought up a German, and we don't seem to be able to cook without using some. To us a meal isn't a meal without potatoes. I love fresh potatoes.

MRS. D: We're a potato-eating family too. We eat potatoes at least once a day. I cook a good amount for our main meal, and then I will fix them another way for lunch.

MODERATOR: Let's ask the question: In what form do you serve potatoes--either fresh or processed?

MRS. SI: Generally fresh. I do enjoy the processed potatoes, though. They are very time-saving and very good, too.

MRS. LI: I'm usually in a hurry, especially on weekends, so it's usually the processed potatoes then. I have to have potatoes once a day. Except in the summer, my teenagers are gone all day and are home only for dinner. Potato chips are constant at our house--3 or 4 bags a week. So we use a lot of potatoes.

MRS. MO: Fresh potatoes.

MODERATOR: Do you also use the processed product?

MRS. MO: On occasion, yes, but we enjoy fresh potatoes fried, mashed, baked, or any way we can fix them.

MRS. LA: I find that a working woman often resorts to processed potatoes. We have fresh potatoes every single day. I find potatoes, along with meat and vegetables, are much cheaper to fill up teenagers than snacks. When I work, I find I can get the frozen hash brown potatoes and quickly fix them any way the family likes them.

MODERATOR: Mrs. O, would you say you are utilizing more potatoes today than you did last year or less, or about the same?

MRS. O: Well, we are a low-consuming family for potatoes. My husband is always trying to avoid carbohydrates, so potatoes are the first thing to get scratched, I'm afraid, and it depends on how strict we are. We really don't use very many potatoes.

MODERATOR: Mrs. D, with 9 in the family, is your potato usage increasing, about the same, or decreasing as compared to last year?

MRS. D: About the same.

MRS. SP: I think we are using more because, as I said, if the kids have a picnic, I always make potato salad, and we have potato chips. No matter what we have, the kids consider there is nothing to eat in the house unless we have potato chips and pop.

MODERATOR: Mrs. MA, you have a small family, what's your consumption pattern?

MRS. MA: Well, we use a lot of fresh potatoes in the wintertime, and frozen potatoes and potato chips and potato salad in the summer.

MODERATOR: Would you say it's on the increase, then?

MRS. MA: Oh, yes.

MODERATOR: Those of you who buy fresh potatoes, what size of bag do you prefer to buy for your family unit? Mrs. D?

MRS. D: The biggest one I can find. I have many times bought them in 100-pound bags. I will do this especially in the fall when you can get the winter potatoes that will keep. They are much cheaper then than they are around this time of the year, when they are very expensive. At other times I get 50- or 20-pound bags, and lately I've been getting 10-pound bags because they don't keep very well right now.

MODERATOR: Mrs. W, what size bag do you buy for your family?

MRS. W: We buy 50-pound bags when we can. Right now it's 20 pounds.

MODERATOR: Are you able to buy the 50's in your stores during the wintertime?

MRS. W: Well, we buy from a market, and usually buy enough to last us over the winter.

MODERATOR: Mrs. LA, what size do you prefer to buy?

MRS. LA: The largest size our store carries is 20 pounds. Occasionally they will have the 25-pound bag.

MRS. SI: In the fall I buy 50 or 100 pounds of potatoes at a time and store them in the basement through the winter, and then as it gets on towards spring and potatoes start to sprout, I start buying them in smaller bags. Then, as they get more expensive, I find sometimes that the instant mashed potatoes and canned potatoes are even cheaper, so I resort to these. I would say we probably use about 8 to 10 pounds a week, which is pretty good consumption for us. I am on a diet, and I find that my potatoes are necessary, and I've lost weight very well on potatoes. I think it's terrible the way people pick on potatoes when they are on diets.

MODERATOR: There are many people out there in the audience who will agree with you on that point. Mrs. MO, what size of bag do you prefer to buy your potatoes in?

MRS. MO: We buy a 10-pound bag, but we use about 20 pounds a week.

MODERATOR: Now, let's find out whether you have had, or are having, any problems in buying fresh potatoes. What would you say is your most serious problem as far as buying fresh potatoes is concerned? Think about the last six months.

MRS. O: I think I may try to keep them too long. They get soft, so I always buy them in very small quantities because, as I said, we don't use them up too fast. But I wonder about the lady who keeps them over the winter. I have never had any success in keeping potatoes, even in a cool place, for more than two or three weeks. They get soft.

MRS. LA: A bad potato in a bag, that's about the smelliest! I do try to get them good; when you buy them by the bag, you can't look them over.

MODERATOR: Have bad potatoes been causing you a real problem?

MRS. LA: I don't think they keep as long as they did years ago. I don't know why.

MRS. D: I think my biggest problem is the variance of size in one bag. I'll buy a bag of Idaho potatoes--that's our Sunday special--and I will have to sort out the whole bag to find the larger ones for baking. I think the potatoes should be graded.

MODERATOR: You think they should be sized more uniformly?

MRS. D: Yes, so we can buy the large potatoes. I suspect that in the store they sometimes pick the great big ones out of every bag and sell them for 15 or 20 cents a pound and then put the rest of them back in. I really do!

MRS. SP: My chief complaint is, how come every bag you buy has to have at least one rotten potato in it--at least one, it's got to. And I have a storage problem, so I use the potatoes up right away.

MODERATOR: You're using Idaho potatoes?

MRS. SP: Any kind. I don't think it's the growers, I think it's the markets. And another complaint I have, I don't think potatoes taste as good as they used to. And we use all fresh potatoes, because half of our kids like frozen potatoes, half like packaged, but they all like fresh. So I use all fresh so there's no complaint. But sometimes you get a good batch and at other times they are green and they just taste funny.

MODERATOR: That's getting to get some discussion a little bit later.

MRS. W: I don't know that I've had too much trouble; although in the spring when the new potatoes come out, once in awhile you get a bad one. One thing I don't like about a potato is to have it get mushy on the outside and not cooked in the middle. But you don't find those as much as you used to.

MRS. K: I usually use Idahos, and I, too, have the complaint that if you're paying--what is it, $1.09 or something for a bag?--you're getting quite a few small potatoes in there. I think these should all be graded.

MODERATOR: You'd like to see them sized more uniformly?

MRS. K: Yes.

MRS. MO: I can agree with Mrs. K on sizing, but in our case the nonsizing helps, because we have two small children, and they love potatoes, but they want the little ones, while our daughter and my husband and I like the biggest ones we can get. So it works fine for us, but I can understand that with a grown family you would want all big potatoes. One thing I do object to is finding a black, rotten potato in the middle of a bag of about ten. The outside looks beautiful, but by the time you cut the bad away, you have thrown about half of the price of your potatoes down the drain. This can be expensive after a while.

MRS. LI: I like California potatoes right now. I think they are beautiful. I like how nice and clean they are. But I do like the mesh bag that Idaho potatoes come in, because I can see what's in there. I don't like these bags with a little window in them because the potatoes may be good right where you can see them, but often when you get them home, the rest of them aren't very nice.

MODERATOR: That will come up for some discussion, too. Mrs. SI?

MRS. SI: I have to agree with the comments of the ladies about sizing, and I also must say that I have often found one or two potatoes in the bag that are bad. Also, on some particular bags--I wish I could remember which kind they were--it has said, "These potatoes are particularly good for potato salad," or "These potatoes are especially good for baking" (of course, we know the Idahos are excellent for baking). I have read articles saying that certain kinds of potatoes are good for potato salad because they have more or less moisture content--I don't remember which--but I do know this is very useful. I would say a little more information on the packaging would be helpful.

MRS. MA: I am afraid I will have to agree with the ladies about finding spoiled potatoes in the bag. That happens quite often. Either that, or potatoes are picked too early and are green and you can't cook them.

MODERATOR: Well, I think the gals have done a mighty decent job of listing their likes and dislikes about fresh potatoes, and I think they've probably posed some challenging questions for most of you potato people; at least I've heard some that I think should be a challenge. Now for about the next 15 minutes let's explore our use patterns and habits as far as processed potato products are concerned. Let's start over here with Mrs. O. How often do you serve processed potato products to your family? And when we're talking about processed, let's think of the following forms: potato chips or shoestring potatoes; frozen french fries; other frozen, such as those some of you mentioned like potato puffs; canned; potato flakes or other dehydrated potato products; and then hashes or soups. These are the general breakdowns of processed potato products. How often do you use these products, Mrs. O?

MRS. O: I would say in summer it's more often because we do consume potato chips quite a bit. Anything that doesn't require cooking for the whole family I would use. So in the summer I would say 4 or 5 times a week I would serve processed potato products.

MODERATOR: In what form would this be mostly, potato chips?

MRS. O: Potato chips, yes.

MODERATOR: What other processed potato products are you serving?

MRS. O: Canned shoestring potatoes, potato sticks, and frozen french fries.

MRS. LA: We use processed potato products about five times a week. I find that in summer, canned potatoes are wonderful, especially when you go out camping. I find that not many stores have the large cans, by the way, for a large family. They do have the small cans, however. We would go to the State park for camping and I thought it was just wonderful to have the potatoes all ready for us. As far as the other kinds are concerned, we have used Tater Tots, the french fries, the hash browns, and we also use potato chips.

MRS. D: I use the frozen french fries for our fish dinners and we use the shoestring potatoes for lunches and as a snack. I think they are cheaper than the chips, although we do use chips, too. And then the whipped potatoes. When fresh potatoes are so very expensive, I don't think it's so extravagant to use the dehydrated potatoes when I am in a hurry.

MRS. SP: Well, we use a lot of potato chips, but this is mainly for snacks, and it depends on how many other kids are in. We use about 8 to 10 bags a week, but we use mainly fresh potatoes. Two of the children and my husband do not care for the boxed potatoes, and the other two don't care for the frozen, so why argue? I just use the fresh and everybody is happy. But for myself I like all the processed products--the frozen, the dried, any of them.

MRS. W: We use mostly fresh. The children are not too fond of the packaged stuff, the frozen or the hashed browns. But quite often we use the canned potatoes which are quite nice for camping trips. And we use the frozen french fries. Occasionally we make our own potato chips. The kids have fun making them, and they taste a little different from the bought ones. We also make frozen french fries, but usually we use the frozen. We like all kinds of potatoes, I guess. But the packaged scalloped potatoes we are not pleased with at all. The kids say they don't taste lke Mom's.

MRS. K: I more or less stick with the fresh potatoes, except for the frozen french fries and some potato chips, and I do like potato flakes. I think they have a very good taste.

MRS. MO: We use hash browns once a week with our fish dinners, but the rest of the time it's usually fresh potatoes. Now, when we go camping we do use the canned shoestring which you were talking about and also the little canned potatoes, but only because it's easier to carry them. But the rest of the time hash browns would be the extent of our use of processed potatoes.

MRS. LI: As I said before, I like to try everything, so I think I've tried almost all of the potato products--potato pancakes, potatoes au gratin, scalloped potatoes, and the mashed potato buds. We like them all. I do think I like my own scalloped potatoes better. The dried ones seem to be a little bit more watery when they are prepared, but as far as potatoes au gratin, I would never go through the trouble of making them when I can buy them in a package all prepared for me. And frozen french fries--my kids love Tasty Fries--they are a mashed potato formed into a french fry and I can stick them into the oven; I don't have to get the grease hot and they don't have the smell the french fries do.

MRS. SI: We use quite a few processed potato products in our family, according to the weather and the activities that are going on. We like the frozen potatoes, and I love the German potato salad in the can. I add a little crumbled bacon and parsley, and it's better than anything I could make. We like the frozen hash browns, and if I am particularly busy, we find these things are wonderful.

MRS. MA: Quite often we use the frozen french fries and the flaked mashed potatoes. They turn out quite well, but we don't particularly care for the buds.

MODERATOR: Now, let's take one more question, and then we're going to open this up for discussion. In the stores in which you shop, are you having any trouble getting the processed potato products you want? Let's start here with Mrs. O. Is your store stocking most of the products you think you would like?

MRS. O: I think we have a good selection.

MRS. LA: I think we have a very good selection.

MRS. D: I appreciate the large containers and a lot of times I can't find them. This is especially true of the potato flakes.

MRS. SP: I think they have a good one, but I don't use them.

MRS. W: Yes, I think they have a pretty good selection where I trade.

MRS. K: We took a tour of a potato-processing plant, and of course when we came back we wanted to use some of their products. They didn't have so many here at that time, but now they do.

MRS. MO: They have a good selection but I have trouble getting the hash browns, which we use. I can go weeks on end without using the merchandise they get, but on their other selections, like potato buds, they do have good qualities.

MRS. LI: I find everything I want.

MRS. SI: So do I.

MRS. MA: Yes.

MODERATOR: Where do you hear about new potato products? What is your source of information about the new and different types of processed potato products on the market? Where do you get this information? Mrs. O?

MRS. O: Coupons in the mail.

MRS. LA: I get coupons in the mail, but also every month I get the Michigan Extension material with all the new things that are coming out, and I surely appreciate it.

MRS. D: I like the demonstrators in the store that have the little samples that you can try.

MODERATOR: But where do you hear about these new products? Is it from in-store demonstrators?

MRS. D: Well, I suppose I first hear about them through the ads in the paper, but I get a chance to try them at these demonstrations.

MRS. SP: I hear about everything from Sheila Morley and from the Extension Service panels.

MRS. W: I get my information through the Extension Service also, and the newspapers, as well as a little shoppers' paper that one of the markets sends around.

MRS. K: I always follow the Extension information, too, and I look at the ads, and anything that's new I am willing to try.

MODERATOR: Is there much couponing in your area?

MRS. K: No, not so much lately.

MRS. MO: I hear about new products from friends and people I talk to. I talk to people in different supermarkets who tell me about this product and that, and some they like, and some they didn't like. I've learned more this way than watching television or reading the papers or anything.

MRS. LI: Well, I see things advertised in the paper, and then I have to go to the store and look for them. Actually, though, I don't see as much advertised as I see in the stores. When I go to the stores, I go up and down each aisle and if there is anything new, I get it.

MRS. SI: I have to agree. I hear about new products by word of mouth from my friends. I like to try new products. I read a lot and see a great deal in the ads.

MRS. MA: I hear about new products mostly from neighbors and from the newspapers. Magazines sometimes.

MODERATOR: None of you have indicated that you feel there is a shortage of information on new products, so may we assume that you feel the information channels are adequate and that you are well informed?

MRS. O: I would say that this is true, with the exception of potatoes. I don't hear too much about potatoes. I was just thinking the other day that we hear a lot about cake mixes, and pop, and diet products; but frankly, I have not seen too much advertising about potato products. Has anybody else?

MRS. SI: For a while there seemed to be articles in some of the ladies' magazines giving information about potatoes, but I haven't seen anything like that lately.

MRS. SP: You never see those nice ads in Better Homes and Gardens about potatoes as you do about other products.

MRS. SI: With maybe a good recipe?

MRS. LA: I think recipes and labels on bags showing what the potatoes are good for are some of the best things that could be done for potato growers.

MODERATOR: Now, we have come to the dialogue section of the program. We have just about 30 minutes. We will give anybody in the audience an opportunity to quiz any one of the panelists or the panel in general on any statement that has been made or any attitude that has been expressed.

QUESTION: Several of the panelists have mentioned greening of potatoes. Are you aware, ladies, what causes greening in potatoes?

MRS. SP: We were told in our consumers' panel that greening was caused by light getting to the potatoes in the store.

MODERATOR: Anyone else want to respond to this?

MRS. MA: Weren't they dug too soon?

MODERATOR: Would anyone in the audience like to respond to that?

RESPONSE: Most of the greening is caused in the store. It does occur whenever light hits the potato, and you ladies who buy 50- and 100-pound bags should be especially careful to store them in a dark place to avoid greening.

QUESTION: How many of you are concerned about loss in nutrients in the preparation of the processed product? Are any of you concerned about possible additives for increasing or improving shelf life or color stabilization? How about loss of nutrients?

MRS. O: I think I would be aware of that, but it depends on how much you use the product. A mother would be much more concerned, I think, about the processing of her meat, perhaps, than potatoes. At least, I would, because we eat a lot more meat than we do potatoes. But some of the other ladies who consume more potatoes might be more concerned than I.

MRS. D: We have been taught that frozen foods are just as nutritious as the fresh. So that solves my problem. As far as the flakes are concerned, I believe just the moisture is removed. I'm not aware of any additives that are put into it.

MRS. LA: We have a wonderful Food and Drug Act and we have a wonderful government that does protect our food, and we trust them.

MODERATOR: I would have to say that the panel here probably does not seriously question the wholesomeness of our foods and is not unduly concerned about food additives. This is a pretty positive note, and I would assume from the response that this is no problem. Any other questions?

QUESTION FROM THE AUDIENCE: In light of the answer to that question, I would like to ask the panel how many of them really read the ingredient list on their packages of processed potato products?

MRS. SI: I am very interested in what it says, primarily because, as I said, I am dieting. I want to know especially what is in these frozen potato products. I do read the labels.

MRS. D: I would appreciate having the number of calories listed on the package.

MRS. MO: We clip all of them, because of my father-in-law, who eats with us and is on a salt-free diet. We save these ingredient lists, and we are amazed at how the percentage of fat or the percentage of salt can change from month to month in the same can or the same product.

MODERATOR: Well, sir, it looks like about 3 ladies out of our 10 do pay attention to the labels and see what ingredients are listed. Any other questions?

QUESTION: Do you ever look for the grade on fresh potatoes, and if so, how does it influence your buying?

MRS. LA: We like Grade A potatoes. The best grade you can buy.

MODERATOR: Could I diplomatically raise the question, Grade A or U.S. No. 1?

MRS. LA: U.S. No. 1. I was thinking of eggs.

MODERATOR: What does this U.S. No. 1 grade mean to you?

MRS. LA: The very best.

MODERATOR: Are you always happy with it?

MRS. SP: No. [This answer concurred in by several other panelists.] I never see any other grade in the store.

MODERATOR: You don't see any unclassified?

MRS. SP: No, and you can't get the 20-pound bags too often, either.

MRS. K: Grade A doesn't refer to the size, either, does it?

MODERATOR: There is an A size, but U.S. No. 1 refers to quality. Now, let's explore this a little. What was it that you didn't like about the last bag of U.S. No. 1 potatoes you bought?

MRS. SP: The rotten potatoes. I don't blame you men for this at all. I think the fault lies somewhere in between you producers and us consumers. They should holler at the stores. They must keep them too long, because you always get at least one, or sometimes four or five, rotten potatoes. And that makes me mad, because they are very expensive. I take them right back to the store. The man at the store hates me.

MODERATOR: Don't be too easy on these fellows. Mrs. D, did you have any dissatisfaction with the last bag of U.S. No. 1 potatoes you purchased?

MRS. D: Yes, the difference in the ages of the potatoes and in the sizes. Usually the potatoes on top are very nice.

MODERATOR: I think the ladies have done a good job in calling this size situation to our attention. Here is one area where I think there is a tremendous amount of improvement possible. U.S. No. 1, A size, for instance, can still have some relatively small potatoes in it and meet the grade.

MRS. K: If you were going to take a 10-pound bag of potatoes for potato salad, and you were just going to scrub them and put them in a kettle to boil, some of the small ones would be done long before the rest, and this I don't like. So if I were going to get a graded potato, I would like a more uniform size in the bag--especially on quantity buying.

QUESTION: Does the brand name on the bag influence your buying the potatoes?

MRS. SP: No. I peek through the hole and then feel around to see if I can notice any wet spots.

MRS. LA: Well, it depends on the season. Certain brands are better at different times of the year.

MODERATOR: If you bought X brand this week, and liked it, would you look for that next week?

MRS. LA: Certainly. If I like it, I'm sold.

MODERATOR: What was the last branded bag you bought, Mrs. LA?

MRS. LA: Michigan.

MODERATOR: And was the brand name on the bag? Do you recall that?

MRS. LA (and others): (No definite response)

MODERATOR: I guess that answers the question. The recall factor is not very good. It is evident that no supplier has developed a consumer franchise or product differentiation in potatoes.

QUESTION: How many different varieties are the ladies familiar with? Mrs. O, can you name some varieties?

MRS. O: Do you mean like Idaho, Maine, etc.?

MODERATOR: Any others like to respond to that question?

PANELIST: In consumers' panel we were shown this Russet potato. It was supposed to be a new potato, I think it's supposed to come out in the fall, isn't it? Anyway, when I see those, I buy those. Isn't it called Red Russet?

MRS. D: Isn't it true that that Russet potato has been on the market a long time, but hasn't been used very much?

MODERATOR: Anybody from Idaho want to respond to that?

PANELIST: From Michigan.

MODERATOR: Oh, from Michigan. How about somebody from Michigan?

No response.

QUESTION: How many of the ladies would like to have the variety name stamped on the package and how many would like to have some indication of the best usage to which the particular potatoes should be put?

MODERATOR: Let's see your hands. Pretty unanimous.

COMMENT FROM AUDIENCE: This is something I have been trying to get across for 30 years.

MODERATOR: The raised hands were in response to both questions. Now let's separate them. First, how many of you would like to see the varietal name stamped on the bag so that you would know what variety of potatoes you were using? Let me see your hands. Six out of 10 would like to see this. Now, how many of you would like to see the recommended usage on the package? Let me see your hands. Ten out of 10 would like to see the recommended usage on the package.

QUESTION: I'd like to ask the ladies if they would be willing to pay a small premium for that information about variety and usage?

MODERATOR: (after polling the panel) Eight of 10 of these women say yes, and I would not like to argue with them, but my guess is if they are like most consumers are, they would not be willing.

MRS. W: Once this information is prepared and put on the bag, there shouldn't be a great amount of additional cost, should there? For the millions of potatoes sold, it couldn't be more than a half cent or a quarter of a cent or a very small fraction.

MODERATOR: Do the rest of you feel this way?

MRS. K: If they educate us on the usage of potatoes, wouldn't that encourage us to buy more because we wouldn't fear getting the wrong types?

MODERATOR: I take it back. Some of these women will.

QUESTION: Perhaps we could ask the question in another way. Would you ladies be willing to buy two or three different types of potatoes in different bags for different uses?

PANEL: (In unison) Yes.

QUESTION: I'd like to ask the ladies' opinion about the baked potatoes served in restaurants.

SEVERAL PANELISTS: They are often not really baked. I think they use the wrong potatoes. They are really not baked potatoes; they are steamed potatoes cooked in foil, and that's not openly baked.

QUESTION: Do you like, dislike, or object to potatoes that have been colored?

PANEL: (No awareness of colored potatoes indicated.)

MODERATOR: Are any of you buying red potatoes?

MRS. K: I have at one time bought red potatoes with the color added. But I couldn't see where it made any difference.

MODERATOR: I guess we can't answer your question.

QUESTION: Can you tell the difference in flavor between a fresh and a processed potato?

PANEL (consensus): Certain products are so good that it is hard to tell the difference, but on other products there are definite quality differences between the fresh and the processed.

MRS. SI: On dehydrated mashed potatoes, the texture of flakes is closer to the natural product than the fine granules.

QUESTION: What about the flakes?

MRS. SI: I love the flakes.

QUESTION: I would like to ask the panel a question about canned potato sticks. How many on the panel are currently using canned potato sticks or shoestring potatoes?

MODERATOR: Let's see your hands. Seven out of 10.

QUESTION: Is your usage increasing?

ONE PANELIST: It depends on recipes. If they give us recipes, we'll use their products.

MODERATOR: There you are. You need a good home service department.

QUESTION: On the potato sticks, are you talking about the product in cans or in flexible bags?

PANEL: In cans. They stay fresher.

QUESTION: What has been your opinion of the boxed simulated potato-chip products?

MRS. SP: Some of them I like and some of them I don't care for. But the kids want potato chips, and they don't consider these potato chips. As far as I am concerned, I like them.

MODERATOR: Mrs. SP is apparently the only lady on our panel who is familiar with the product you are talking about, sir.

QUESTION: Do the panel members using french fries use them only as such, or in other related casserole dishes, and would they use recipes that show the many other uses for french fries and other processed potato products if the manufacturers would provide them?

PANEL: These are mostly used as french fries. They would be put to other uses if recipes were provided.

MRS. K: I object to all the little teeny pieces I sometimes find in bags of french fried potatoes. Don't they separate the large pieces from the small ones? Don't they have machinery to slice these pieces uniformly?

REPLY FROM AUDIENCE: The feedback from our market tests has been that people want small french fries.

MRS. SP: I am disgusted with one particular brand that I get which consists of all little pieces. They seem to use all the ends of the potatoes.

Of course, if you want real crisp little pieces of potatoes, this is fine, but if you want french fries, you don't get them. I have ceased to buy this product.

COMMENT FROM AUDIENCE: The particular product named by the lady is a B grade product and sells at a lower price.

MRS. D: I would say it should be labelled thusly.

AUDIENCE COMMENT: You have to have a little bit of caveat emptor, or the market wouldn't be what it is.

MRS. LA: I would like to ask the potato growers if all french-fried potatoes turn a little bit dark in freezing. I found quite a few bags that are just a grayish color, and to me they are not an appealing product.

ANSWER FROM AUDIENCE: Many fresh cooked potatoes are apt to darken; I don't think the freezing itself is responsible.

ANOTHER COMMENT FROM THE AUDIENCE: It's the same thing you get in the stem end of the potato, an after-cooking darkening, which I am sure you have all experienced. A processor is not on the ball unless he prevents it by the use of sodium acid pyrophosphate. This is a leavening agent, a perfectly wholesome substance, as good as salt and pepper, or perhaps even better.

QUESTION: What is your objection to potatoes steamed in foil? Do you attribute it to flavor changes or texture changes?

PANELIST: Texture change. And it doesn't taste like a potato baked without foil in an oven. The skin is softer of course, but it does not improve the flavor of the potato. I think they do it in restaurants because it hastens the baking time.

QUESTION: Looking toward the future, ladies, if you could buy fresh potatoes cut, or sliced, or diced, or what-not, in a film package in your supermarket which would last for two or three weeks or so, would you buy this in preference to potatoes with the skin on that you have to peel yourself?

MRS. MO: No, because we enjoy the potato skins. We boil them or bake them with the jackets on and eat the jackets. We don't throw the skins away in our house. To take them off would spoil the potato.

MRS. SI: I would like to see a comparison on prices. If the price were comparable, I would be glad to use them.

MRS. SP: It seems to me you might lose some nutrition that way.

MRS. K: I have a kind of pet peeve. Frozen products. Many of these products as you buy them in the store are only half frozen, and then they melt some more before you get them into your freezer. I don't think this is the fault of the grower or the processor, but I don't like it. I think there should be better distribution of frozen products so they go right into the frozen-food containers in the store and they don't stand around unfrozen for long periods of time, as I have often seen them.

MRS. LI: This is the fault of the stores.

QUESTION: Prepeelers have been supplying institutions--hotels, restaurants, hospitals, etc.--for a number of years with potatoes that are peeled, including those that are french-fry cut. Others who are trying to get into the field are partially frying the french-fry cuts and refrigerating (not freezing) them. How would you as consumers accept a product like that?

MRS. LI: Don't you think you'd have to go to quantity cooking to make this worthwhile? I think something like this might be good, but if you were only cooking for a small family, would it be worthwhile?

MRS. LA: A working housewife might want to purchase a package of these pre-fried french fries occasionally, but I don't think she would do it as a steady rule.

MRS. SI: I find that when I go to the store I buy the fresh potatoes, I buy the canned, I buy the frozen, and the dried. So I'm using all varieties, and if I found some of these frozen products were available, I might use a little more. But nothing can take the place of fresh potatoes.

MODERATOR: I would gather from what these ladies are saying that you might be able to develop a franchise for this type of product, but that they basically feel they've got a pretty adequate supply and variety of product forms.

COMMENT FROM AUDIENCE: But they are very intelligent ladies, and I am sure they would change their minds.

QUESTION: When you say there is nothing like a fresh potato, what are you mainly talking about, flavor or texture or both? Can you pin it down? This is very important to everybody in the utilization of potatoes.

MRS. SP: This is kind of a hard question to answer. On baked potatoes, of course, you can't use anything but a fresh potato. We like boiled potatoes with the skins on. I think that the difference between the processed and the fresh must be in the flavor.

QUESTION: How about the mashed product? Is it flavor or texture?

MRS. SP: It would be texture there.

MODERATOR: I think what the lady is trying to say to you, sir, is that the fresh product has certain qualities which are unique, and that they provide some satisfaction that none of today's processed product have been able to.

QUESTION: Why do you boil potatoes with the skins on? Is it for flavor?

PANELIST: No, when I boil potatoes with the peels on, first we eat them that way and then I put them in the icebox, and then if they're nice potatoes I bake them up that way with the skins on. Otherwise, I take the skins off and fry them. I think they keep better with the peels on and I do like the flavor of the peel.

MODERATOR: I would say that today's panel is representative of the middle-class, middle-income, consuming unit in Michigan. We have two on the panel with relatively young families; but by and large, the panel represents the large middle segment of our consuming population. As such, it is biased in that manner. However, I would say that we have succeeded in getting a panel here of middle-income people who use potatoes in bulk, processed, and fresh forms. If you go out and select a panel at random, the chances are pretty good that you will end up with only 3 people out of the 10 who regularly use potatoes. We didn't feel that a panel like that would be very meaningful for you. Because we wanted to hear from people who had been using or were using potatoes, we biased our selection in this way.

QUESTION: Have any of you ladies noticed in preparing potatoes for a meal, either by boiling or by baking, that the potatoes do not boil the same or bake the same?

PANEL: Yes (unanimously).

QUESTION: I'd like to know if the ladies are concerned with the protein or vitamin content of the potatoes or just with their carbohydrate or stomach-filling properties?

MRS. SP: The stomach-filling properties.

MRS. LA: I am very conscious of the protein end of it, too.

MODERATOR: I think you can see here again we are talking about a middle class, so you are talking about some discretionary purchasing power. The concern is not going to be like it is with a relatively young family; and if we developed some information on their discretionary spending power, you could get some idea why the panel is not atypical of the general public.

QUESTION: I'd like to know whether the ladies prefer washed or unwashed potatoes.

PANEL: Washed (unanimously).

QUESTION: What was your concern about the texture of the processed mashed potato product?

MRS. K: I like the flakes best, because the texture is more like a fresh mashed potato when you add milk and butter.

MRS. D: I disagree. I have powder that is very good, and I don't care quite so much for the flakes.

MRS. LI: And I use the potato buds, and I like them real well.

MODERATOR: We've got something for everybody. I think we should appreciate the fact that these ladies took a day off of their time. They all have families and have gone out of their way to spend this hour and a half with you this morning. Let's give them a big hand.

NUTRITIONAL VALUE OF THE POTATO IN RELATION TO THE FOOD SERVICE INDUSTRY

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Good afternoon, ladies and gentlemen, members of the conference, and others interested in the potato world. I am riding in here, so to speak, on my husband's coattails because of my interest in good nutrition and as a teacher in the food service industry. For many years, and particularly during the past 15 years, it has been my privilege to try to interest students in the School of Hotel Administration at Cornell University in the basic chemical knowledge of foodstuffs and in the reactions which take place during food preparation.

Some materials are handled too sketchily, but not the potato. Dr. Ora Smith generally gives two lectures on potatoes to my students. The lectures cover the types of potatoes, their standards, the uses for which they are purchased, testing with the hydrometer, separation by specific gravity, and a brief survey of processed potato products. The time is inadequate to cover a subject one has spent a lifetime working in, but it is sufficient, along with several laboratory sessions, to give food-oriented students a glimpse into this area. It also provides them sources of information for the answers to questions that come up later in their hotel and restaurant work.

Potatoes are still a major item in the diet of Americans, whether they are eating at home or eating out, whether the potatoes are fresh, frozen, dehydrated, canned or in any other processed form such as soup, chips, french fries, crackers, cakes, doughnuts, cookies, or candies. We all like potatoes in any form, and they are available year-round.

The basic composition of the potato is given in Table I:

TABLE I.--Proximate analysis of potatoes (19)

Component	Average (Percent)	Range (Percent)
Water	77.5	63.2 - 86.9
Total solids	22.5	13.1 - 36.8
Protein	2.0	0.7 - 4.6
Fat	0.1	0.02 - 0.96
Carbohydrate	19.4	13.3 - 30.53
Crude fiber	0.6	0.17 - 3.48
Ash	1.0	0.44 - 1.9

Potatoes are utilized as a source of energy and vitamin C; the average consumption per person per year is approximately 110-112 pounds of raw product. Potatoes are mild, and they blend easily into the flavor and texture of most types of meals. Texture varies according to many growing factors and varietal differences. It is interesting that this vegetable is used in so many different forms. I cannot think of any other that can compare to it in this respect and, of course, this adds to the tremendous number of recipes using the potato, raw or processed. Just think of the many recipes utilizing potato chips. Some 10,000 recipes are submitted to the Potato Chip Institute Men's Cooking Contest each year. Of course, there are duplicates, but the variations submitted are interesting. Chips are a very popular processed form, as shown by the growth of the industry and the increasing volume of sales each year.

Other processed forms are interesting and popular, too. In an article on the potential of the processed potato, Julius Brody (7) includes the following interesting table (which I have expanded by adding the material shown in parentheses):

TABLE II.--Potatoes: How processed, how used

Dehydrated diced potatoes, sliced potatoes and stew cuts	Canned hash, dog food, frozen pot pies, canned stews, salads and snack items
Dehydrofrozen diced, julienne style cut, slices and stew cuts	Canned soups, beef stews, sliced beef and gravy, au gratin, scalloped, etc.; frozen stews and au gratin, etc.
Dehydrated instant potato granules and flakes (buds)	Frozen dinners, mashed potatoes, frozen stuffed potatoes and snack items
Frozen french fries and potato rounds	Frozen dinners
(Frozen whole potatoes and frozen hash brown)	(Institutional and restaurant and fast food items)
Prepeeled and processed potatoes	Institutional and restaurant--trade items

The remainder of Brody's article reviews such matters as the solids content, discoloration, and texture of potatoes, storage conditions, and microwave chip drying, and also provides a checklist of potato varieties and properties, and their applications in foodstuffs.

The following table, also from Brody's article, relates specific gravity or total solids of raw potatoes to their cooked texture and adapted use.

TABLE III.--Solids content required for a given application (7)

Specific gravity	Total solids (Percent)	Texture	Best use
Below 1.060	Less than 16	Very soggy	Good for pan frying, salads; fair for boiling
1.061 - 1.070	16-18	Soggy	Good for pan frying, salads; fair for boiling
1.071 - 1.080	18-20	Waxy	Good for boiling and mashing
1.081 - 1.090	20-22	Mealy	Good for baking, mashing, making chips and french fries
Above 1.090	22-24	Very mealy	Good for baking, making chips and french fries

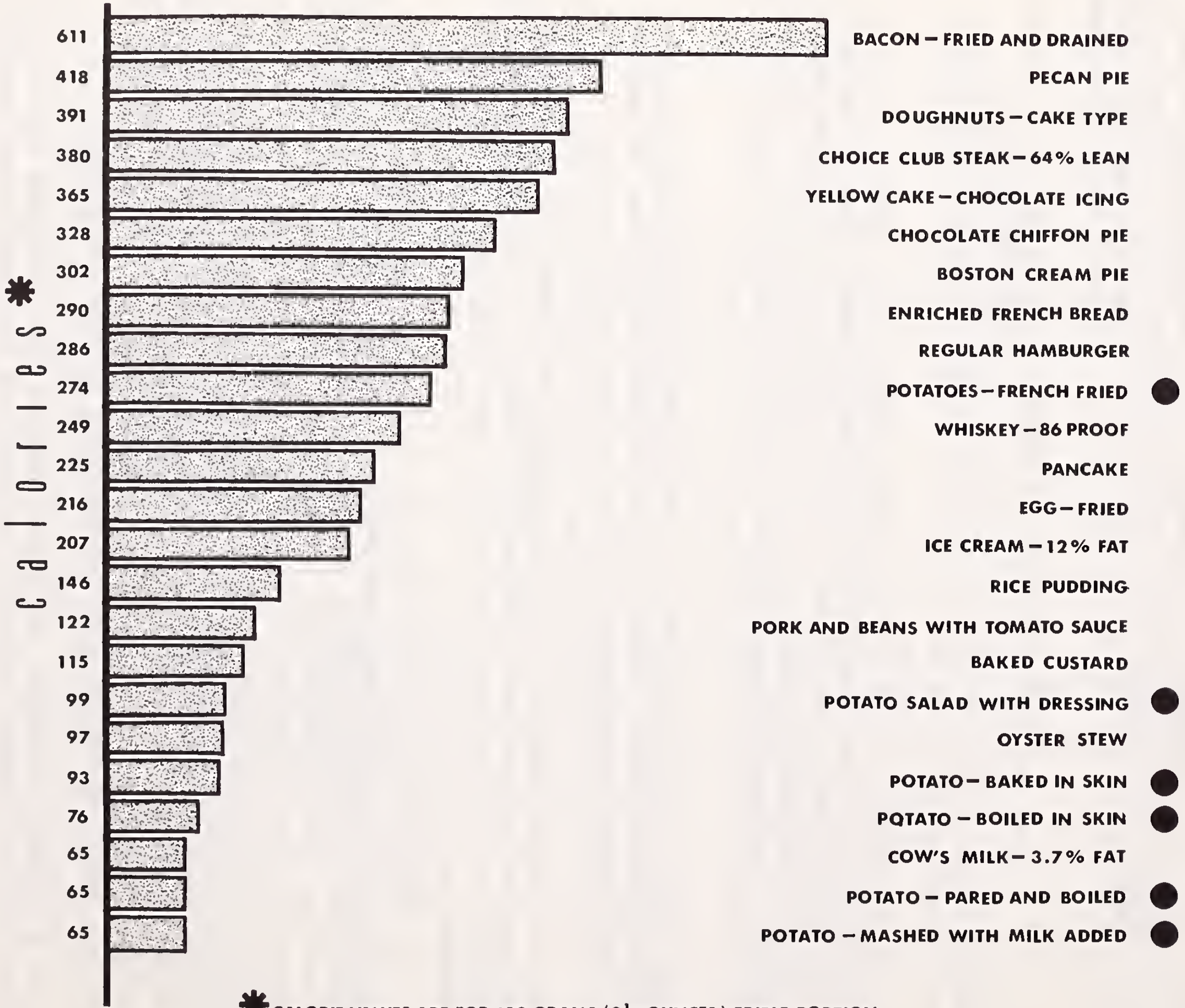
May I comment on the terms "soggy," "waxy," and "mealy." Many of our students prefer the so-called "soggy" or "waxy" types. These terms have several interpretations in the texture field, and most feel that the best description for them is that they are not dry. In the 1.071 - 1.080 range, however, there needs to be some differentiation; the lower specific gravity refers to the boilers and the higher specific gravity to the bakers.

A recent advertisement of the Washington State Potato Commission says that "Potatoes are always something else because they are so versatile." An Idaho advertisement stresses the "talent" of the potato in such terms as, "Serve the potato that does everything." The all-purpose potato as such has not been developed; however, by understanding the chemical composition of potatoes and the various tests devised for them--the specific gravity test, for example--one can separate them roughly into categories to better fit specific uses.

The versatile potato not only can be used in many ways and forms, it is also quite nutritious and very adaptable to extended or additive nutrition. There has been little nutritional disease in those areas of the world where the potato has been a stable part of the diet. Let's examine the caloric value by reviewing a chart prepared by the United Fresh Fruit and Vegetable Association's Information Department for the Potato Division, entitled "So You Think Potatoes are Fattening?" (figure 1). This chart certainly speaks for itself, and I think people interested in potatoes should carry it around with them. I also think it should be produced in poster form for schools, restaurants, etc. The caloric content of the baked potato is only slightly higher than that of the boiled, unpeeled potato, but the nutrient content is higher.

In a Cornell Extension Bulletin, Dudgeon (11) stresses that no food is fattening until the body's need for calories has been met; then, surplus food

....so you think potatoes are fattening?



*CALORIE VALUES ARE FOR 100 GRAMS (3½ OUNCES) EDIBLE PORTION

Any food that contains calories is "fattening" if the amount of calories consumed is greater than the amount used. The surplus is stored up in the form of fat. Potatoes provide a highly digestible bulk with relatively few calories (it would take about 10 pounds of potatoes to provide the daily caloric requirements of a young adult). Potatoes also contain generous quantities of important nutrients. As a source of vitamin C, potatoes are recognized as being a close second to citrus in providing each American's total supply.

UNITED POTATO DIVISION

United Fresh Fruit & Vegetable Association
777 14th Street, N.W.
Washington, D.C. 20005

Figure 1. Caloric value of potatoes as compared to that of other foods.

is converted to fat and stored. One medium-sized potato supplies about 3 percent of the total energy needed. A successful experiment at Douglass College several years ago with a group of overweight students demonstrated that potatoes can be successfully included in a reducing diet (3). This brings to mind a recent article by Dr. Anthony Downs (10) in which he observes that the emphasis in merchandising is on either "sex" or "diet." One or the other of these terms must apply to the appetites of 90 percent of our 12.7 million teenage girls who say they eat snacks at least once a day. Fifty percent of them say they snack at least twice a day, their favorites being cookies, fruit, potato chips, soft drinks, ice cream, and candy. Most of us realize that teenage boys never seem to be full--they are eating most of the time. This brings up the school lunch program and another phase of potato nutrition, namely the vitamin content.

Dr. Ruth Leverton of the U.S.D.A., speaking at the 51st Annual Meeting of the American Dietetic Association in October 1968, mentioned the necessity of certain foods, such as dehydrated potato flakes, to be fortified with ascorbic acid for distribution to needy families. Vitamin-C-restored instant mashed potatoes have been added to the list of foods recommended for Federally-reimbursed schools participating in the National School Lunch Program. A one-half cup serving of reconstituted dehydrated potatoes with the vitamin content restored may be used as the vegetable-supplied vitamin C of the Type A School Lunch. The companies producing the fortified dehydrated potato as instant flakes or buds are offering methods, recipes, and menus to the schools.

On the stability of vitamin C in fortified potato flakes, Cording et al. wrote (8):

> In the flake process, a retention of both natural and added vitamin C during processing is 71-73%. On storage for 28 weeks at 75°F. in an air pack, flakes of 5% moisture containing antioxidant retained 70-76% of the natural and added vitamin C remaining after processing. In a nitrogen pack, substantially all of the vitamin C that survived processing was retained after 28 weeks of storage.....

Fortification with vitamin B_1 appears uneconomical because of processing losses due to the presence of sulfite. Based on retention, fortification with vitamins A, B_2, and niacin seems practical. A yellow color in the reconstituted flakes of some lots was attributed to vitamin B_2. A small panel did not consider the degree of color undesirable. However, the flavor of these same lots when reconstituted was considered inferior to the standard, and was attributed to "multi-vitamin combination in these lots." (8)

A study of the total ascorbic acid of shoe string potatoes (1/4- by 1/4-inch) as compared with french fries (1/2- by 1/2-inch) was made by Bring of the University of Idaho (6). The fresh shoe strings retained about 20 percent more total ascorbic acid than heated frozen samples in October and 41 percent more in April on a dry solids-not-fat basis. Later in her discussion, Bring makes a point of the importance of the time of processing--whether at the beginning of the processing season or near the end. This is implied by the following results:

TABLE IV.--Ascorbic acid in potato products processed at beginning and end of season (6)

Time of analysis	Mg. total ascorbic acid per serving*		
	Flakes	Granules	Heated frozen shoe strings
Beginning of processing season	8	6.6	13.8
End of processing season	2.8	2.1	4.8

*Flakes and granules, 1/2 cup; shoe strings, 30 pieces (3 x 1/4 x 1/4 in.)

The effect of storage period on total ascorbic acid content of frozen shoe string potatoes was insignificant, Bring reports, up to 5-1/2 months of storage at a temperature range of -23.5 to -10.5 degrees C. The greatest loss was during the first 28 days of storage; this amounted to 6.4 mg. per 100 g. of dry solids-not-fat weight. Mean percentage of fat in these samples of heated frozen shoe string potatoes ranged from 12.8 at production to 10.6 after 28 days of storage. The recommended daily requirement of ascorbic acid is 2.5 mg. per kg. of body weight or 60 mg. for a 70-kg. man (154 lb.) (13).

The vitamin C content of heated frozen french fries is given as 20 mg. per 100 g., and now it will be interesting to see what the vitamin C content will be in the newer french fries that are blanched to produce a translucent appearance before being dehydrated, fried in deep fat for 15 to 60 seconds and frozen.

Dehydrated potato products fortified with vitamin A so far have not been marketed. Vitamin A is so readily obtained from green and yellow vegetables as well as from other sources that it does not appear a real necessity to fortify potatoes with vitamin A.

From a recent article by Polansky (18) on the vitamin B_6 components of fresh and dried vegetables, I have extracted the data on potatoes shown in Table V. Differences between the values for the unchromatographed vitamin B_6 and the sum of its chromatographically separated components were not significant.

Potatoes rated over 1.6 µg vitamin B_6 per gram along with members of the cabbage family, carrots, green peppers, yellow onions, spinach, sweet corn, and turnip greens. In most cases of peeled and unpeeled vegetables such as potatoes, the vitamin B_6 content of the peel was different from that of the peeled product, but when combined to form the total edible, the total B_6 was not appreciably influenced by the peel since the percentage of the peel is quite low.

TABLE V.--Values for vitamin B_6 components and proximate composition of potatoes (18)

Potatoes	Total solids	Fat	Kjeldahl	Ash	Vitamin B_6 (μg./gm.)				
					Unchromatographed	Chromatographed			
						Sum	Pyridoxine	Pyridoxal	Pyridoxalamine
	%	%	N%	%					
Maine Russett									
Baking peeled	20.3	0.0	0.32	0.80	2.41	2.37	1.81	0.34	0.22
Peels	17.6	0.1	0.50	1.25	1.50	1.57	0.81	0.53	0.23
Total edible	20.0	0.0	0.33	0.84	2.33	2.30	1.72	0.36	0.22
New, Red, Mexico									
Peeled	18.6	0.0	0.25	1.08	1.81	1.82	1.18	0.40	0.24
Peels	18.7	0.1	0.32	1.31	1.50	1.63	0.87	0.53	0.23
Total edible	18.6	0.0	0.26	1.11	1.78	1.80	1.15	0.41	0.24
New, White, Mexico									
Peeled	19.3	0.0	0.30	0.92	1.71	1.82	1.17	0.27	0.38
Peels	17.1	0.1	0.32	1.29	1.54	1.82	0.93	0.46	0.43
Total edible	19.1	0.0	0.30	0.95	1.70	1.82	1.15	0.29	0.39

Therefore, on the basis of daily intake of 2.0 mg. of vitamin B_6 per day for adults (13), the potatoes thus analyzed in the preceding article would contribute approximately 0.160µg. per 100 g. portion. Page and Hannings(17) summarized their findings as follows:

> The studies with boiled potatoes showed the solubilities of niacin and vitamin B_6 to be similar. Means of 16.6 percent of the niacin and 15.2 percent of the vitamin B_6 in the raw potatoes were found in the cooking water. However, the destruction which occurred during cooking was somewhat greater for vitamin B_6, being 4.8 and 8.8 percent for boiled and baked potatoes respectively, as compared with 1.5 and 4.2 percent noted for niacin. According to these data, 100 g. boiled, peeled potatoes provided, on the average, 1.35 mg. niacin (1.75 niacin equivalents) and 0.21 mg. vitamin B_6. Baked potatoes contained 1.84 mg. niacin (2.24 niacin equivalents) and 0.28 mg. vitamin B_6. Since the adult recommended allowance for niacin is 17 to 21 niacin equivalents, a 100-g. serving of boiled or baked potatoes would thus furnish approximately one-tenth of the allowance for this vitamin.

Page and Hannings (17) also reported on the effect of storage on niacin and vitamin B_6. Wisconsin Cobblers and Triumphs withstood 6 months of storage at 40 degrees F. with no significant change in niacin and 2-1/2 times the amount of vitamin B_6 at harvest. Minnesota Cobblers and Sebagos, on the other hand, stored for 1 month at 75 degrees F., were lower in niacin and higher in vitamin B_6 than those held the same length of time at 40 degrees F.

The protein of the potato is important in that it evidently is complete, containing all the essential amino acids demanded by both man and the rat. The proteins of tubers are made up of 60 to 70 percent globulins and 20 to 40 percent glutelins. The glutelins contain more cystine, aspartic acid, proline and tryptophane than do the globulins. Free amino acids make up 40 to 50 percent of the nonprotein nitrogen.

The essential amino acids present in the protein are equivalent to those of casein and, in addition, lysine is present.

The biological value of protein in the potato compares with proteins of animal origin. Twenty-one amino acids have been identified. These are cystine, glutamine, alpha amino N-butyric acid, histidine, arginine, lysine, proline, methionine sulfoxide, valine, methionine, isoleucine, phenylalanine, aspartic acid, glutamic acid, serine, lysine, asparagine, threonine, alanine, tryptophane, and tyrosine. Some differences in the content of amino acids in potatoes which have been boiled, chipped, french fried, and mashed have been shown.

Clive McCay has stated (15) that each time his laboratory made a study of potatoes, their nutritive value became more apparent. His results indicate that the protein of the potato is utilized, and that the balance of other nutrients are such as to give good health and long life to rats, dogs and man. One-third of the dry matter of these balanced diets was provided by potatoes and was compared with good bread, such as the Cornell formula bread (12).

The fat content of the potato is low, averaging 0.1 percent on a fresh weight basis with the concentration greatest in the periderm. The fatty acids present, according to Cotrufo and Lunsetter (9), are linoleic (41.3 percent), palmitic (24.9 percent), linolenic (19.4 percent), oleic (6.6 percent), stearic (5.4 percent), and myristic (0.6 percent). Therefore, the majority (over 60 percent) of fatty acids present are of the unsaturated type. Thus, the small amount of fats or lipids present is nutritionally sound.

Potatoes, though modest in the concentration of food components except carbohydrates and water, do contribute substantially to American diets, furnishing 2.5 percent of the calories and about 17 percent of the ascorbic acid.

With reference to minerals, the potato plays a role in low-sodium diets of the hospital menu (20). Since the recent emphasis on sodium-potassium ratio, the potato as a source of potassium has again come to the foreground. Besides these two elements, the potato contains Ca, Cl, Co, I, Fe, Mg, Mn, P, S, and Zn. Those minerals that are not leached out in soaking or cooking water add to the human source of minerals. Those present in the peel or in the outer layers of the potato are saved in the baked whole product.

It has often been stated that the food-service industry cares little about the nutritional attributes of the food put before the public. Its first interest is, of course, to make money, and in the area of school and hospital services, not to lose money. However, in all cases, nothing is gained unless the food furnished is consumed. The garbage pail certainly expresses very well what is liked and what is eaten.

To change people's food habits is a long, drawn-out process involving a goodly amount of education by all the media that are available. However, meat and potatoes have been and still are the foundation of the main meal of the day. This is true in spite of the modern surge for gourmet-type meals. Since the field of potatoes is the specialty of this gathering, it seems apropos to discuss the nutritive value of the potato and its use in this very large area of food service.

Included in food service are the services provided by the hotel and motel restaurants, commercial specialty restaurants, diners, fast-service chains, airlines, in-plant restaurants or cafeterias, hospitals, institutions, and school-lunch programs.

Many of the trade magazines have indicated through surveys that the public is "eating out" more and more. The older generation has added its numbers to those who enjoy a meal out. Many prefer lunch to dinner, and many feel that one good meal a day meets their daily needs.

What role does and can the potato play, and what should be emphasized?

Potatoes are used as fresh produce. The emphasis here is on the baked fresh potato. The other use is the prepeeled product for boiling, salads, and oven browns. In the frozen state, the main products are french fries, but some potatoes are hash browned, and some are frozen whole for oven browning and creaming. Canned potatoes are used for oven browning and creaming. Then the dehydrated types--granules, flakes, buds, slices, nuggets--are all widely used for mashed potatoes, pan fries, salads, etc. Potato flour is used in the manufacture of synthetic chips, french fries, sauces, gravies, and in various cake mixes. The potato chip, a completely pre-prepared product, along with potato sticks and nibbits certainly corner a good share of the snack market.

Food Service devoted a large part of its July 1968 issue to the potato "renaissance" (4). The purpose was to present the potato in its many forms in interesting culinary concoctions, both old and new. This issue advocated use of the potato around the clock as well as around the year. A table of new market forms and how they are portioned and sold to the food-service industry was given as well as uses of the various forms. The article suggested an instant potato omelet for breakfast, a profit-promising potato salad, a special for gourmet lunch buffets called "Potato Salad Nordica," and a country potato cake for dessert.

With a bit of imagination along with the basic knowledge of a product, many nutritious dishes are possible to offer the public. Many years ago, egg was introduced to infants by adding it to cooked cereal or mashed potatoes. Now the protein content of a well-prepared instant mashed potato can be raised by adding egg plus grated cheese and other ingredients. The dish can be served hot or frozen and reheated in deep fat or in an oven, or it can be used as a patty or a fancy rosette from the pastry tube or a garnish for a broiled steak platter. Chives, parsley, and other mixtures of spices have been used as additives to instant mashed potatoes to enhance or give a new flavor.

An article in the magazine, Institutions, entitled "Savoir Fare: Sophisticated Meat and Potatoes," (5) says there is no more acceptable menu to about 20 million Americans who were young in the Thirties than a good meat loaf, boiled potatoes in their jackets, a green salad, topped off with an old-fashioned bread pudding.

Another article, this one in Cooking for Profit, describes french fries as "indispensable" (1). It speaks of the many varieties and uses of such frozen products as regular-cut and crinkle-cut potatoes, shoe strings, and rounds. Also mentioned is the success of a California franchise in adding french fries to its basic hot-dog menu. We all have had experience from our children and grandchildren of the superior french fries of the many drive-in operations. The new frozen types with from 10 to 15 percent fat certainly will be a relief to the calorie-conscious. Some of the dehydrated mixes for french fries are convenient and quite acceptable.

The rosin-baked potato is being promoted, not only to increase sales and profit, but to improve the quality of the potatoes served. This certainly is an improvement over the steam potato prepared in foil, especially if the original potato was of poor quality prior to being foil-baked.

The article, "In the Chips," (2) which is based on a statistical survey, brings out not only the increase in variety of processed potatoes but also the increase in consumption of frozen or other processed potatoes. One survey of chain-store operations predicts that in ten years the fresh product will be off the market. Potato chips and synthetic potato chips (those made from potato flour) are considered an energy food and perhaps could contribute some protein or amino acids not destroyed by the cooking temperatures. Jacobs and Sharma (14) maintain that animals eat for calories, and hunger affects taste more than calories. Chips appeal to both taste and caloric value.

In the area of convenience foods, I should like to close with the proximate composition of ready-to-serve potato products as given by Murphy *et al.* (16). These results seem to indicate that for all products containing milk, except mashed potatoes, dehydrated mixes when prepared for serving tend to be higher in percentage of carbohydrate and ash than their home-prepared counterparts. Frozen soups and potatoes au gratin were found to be closest to those prepared at home in their proportions of most compounds. In dehydrated mashed potatoes, where some contained milk solids and some varied in fat, or called for use of table fat in reconstitution, the average was somewhat higher in fat and protein than the home-prepared product. Scalloped dehydrated mixes were lower in fat and protein as compared to home-prepared scalloped potatoes. The following information was given in the article:

TABLE VI.--Food energy and fat and protein content of ready-to-eat potato products

Product	Food energy (Calories/100 g.)	Fat (G./100 g.)	Protein (G./100 g.)
Chips (average of 4 brands)	531.5	33.9	7.2
French fries:			
Home recipe	224	8.8	4.9
Frozen (skillet heated, 7 brands)	367	21.8	3.7
Frozen (oven heated)	269	10.4	3.8
Hash browns:			
Home recipe	131	4.4	3.0
Dehydrated mix	177	8.5	2.0
Frozen	214	10.7	1.8
Mashed (average of 4 brands):			
Home recipe	77	0.5	2.2
Dehydrated mix	83	1.3	2.45

*The table was averaged from figures given in article by Murphy *et al.*(16) based on 100 grams prepared for each product. The article also gives figures for scalloped and au gratin potatoes as well as for potato soup.

TABLE VII.--Composition of foods, 100 grams, 3-1/2 oz. edible portion (25)
(Parentheses indicate imputed value)

Food and description	Water	Food energy	Pro-tein	Fat	Carbohydrate		Ash	Cal-cium	Phos-phorus	Iron	Vita-min A value	Thia-min	Ribo-flavin	Nia-cin	Ascorbic acid
					Total	Fiber									
	Pct.	Cal.	Gm.	Gm.	Gm.	Gm.	Gm.	Mg.	Mg.	Mg.	I. U.	Mg.	Mg.	Mg.	Mg.
POTATOES															
Raw	79.8	76	2.1	0.1	17.1	0.5	0.9	7	53	0.6	20	0.10	0.04	1.2	20*
Cooked:															
Baked in skin	75.1	93	2.6	.1	21.1	.6	1.1	9	65	.7	20	.10	.05	1.7	20
Boiled in skin	79.8	76	2.1	.1	17.1	.5	0.9	7	53	.6	20	.10	.04	1.5	16
Boiled, pared before cooking	82.8	65	1.9	.1	14.5	.5	.7	6	56	.7	20	.09	.03	1.2	16
French fried	44.7	274	4.3	13.2	36.0	1.0	1.8	15	111	1.3	50	.13	.11	3.1	21
Fried from raw	46.9	268	4.0	14.2	32.6	1.0	2.3	15	101	1.1	40	.12	.07	2.8	19
Hash-browned after holding overnight	54.2	229	3.1	11.7	29.1	.8	1.9	12	79	0.9	30	.08	.05	2.1	19
Mashed, milk added	82.8	65	2.1	.7	13.0	.4	1.4	24	49	.4	40	.08	.05	1.0	10
Mashed, milk and table fat added	79.8	94	2.1	4.3	12.3	.4	1.5	24	48	.4	260	.08	.05	1.0	9
Canned:															
Solids and liquids	88.5	44	1.1	0.2	9.8	.2	.4	(4)	(30)	(.3)	10	.04	.02	.6	13
Dehydrated mashed:															
Flakes without milk:															
Dry form	5.2	364	7.2	.6	84.0	(1.6)	3.0	35	(173)	1.7	Trace	.23	.06	5.4	32
Prepared, water, milk, table fat added	79.3	93	1.9	3.2	14.5	.3	1.1	31	47	.3	130	.04	.04	.9	5
Granules without milk:															
Dry form	7.1	352	8.3	.6	80.4	1.4	3.6	44	203	2.4	Trace	.16	.11	4.9	19
Prepared, water, milk, table fat added	78.6	96	2.0	3.6	14.4	.2	1.4	32	52	.5	110	.04	.05	.7	3
Granules with milk:															
Dry form	6.3	358	10.9	1.1	77.7	1.5	4.0	42	237	3.5	60	.19	.30	4.2	16
Prepared, water, table fat added	81.4	79	2.0	2.2	13.1	.3	1.3	31	44	.6	90	.03	.05	.8	3
Frozen:															
Diced, to hash-brown															
Not thawed	81.0	73	1.2	Tr.	17.4	.4	.4	10	30	.7	Trace	.07	.01	.6	9
Cooked, hash-browned	56.1	224	2.0	11.5	29.0	.7	1.4	18	50	1.2	Trace	.07	.02	1.0	8
French-fried:															
Not thawed	63.5	170	2.8	6.5	26.1	.6	1.1	7	67	1.4	Trace	.14	.02	2.1	20
Heated	52.9	220	3.6	8.4	33.7	.7	1.4	9	86	1.8	Trace	.14	.02	2.6	21
Mashed:															
Not thawed	80.4	75	1.7	.1	17.1	.4	.7	16	39	.7	30	.07	.03	.8	6
Heated	78.3	93	1.8	2.8	15.7	.4	1.4	25	42	.6	140	.06	.04	.7	4
POTATO CHIPS	1.8	568	5.3	39.8	50.0	(1.6)	3.1	40	139	1.8	Trace	.21	.07	4.8	16
POTATO FLOUR	7.6	351	8.0	.8	79.9	1.6	3.7	33	178	17.2	Trace	.42	.14	3.4	(19)

*Year round average. Recently dug potatoes contain about 24 mg. of ascorbic acid per 100 gm. The value is only half as high after 3 months of storage and about one-third as high when potatoes have been stored as long as six months.

This table is greatly enhanced by comparing its values with the nutritive values of raw, cooked, and processed potatoes as given in Table VII (21). The food value of the potato can be retained both at home and in the food service industry if properly prepared.

The food value of the potato as a source of energy and vitamin C in the daily diet continues to be relatively true. The content of vitamin C has been restored to its nonprocessed value through fortification in some dehydrated granules or flakes. The protein content of the many forms of potato products does not vary greatly; it does furnish the essential amino acids and nitrogen compounds necessary for growth, reproduction, and maintenance. When the potato products are augmented with milk, cheese or eggs, etc., the potato serving begins to approach the daily requirement of protein estimated as 0.9 g. per kg. of body weight. An increase in the protein content of the potato could be an area of improvement for the potato breeder; thus another source of protein could be added to the world menu.

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THE INSTITUTIONAL FEEDING INDUSTRY FROM A POTATO PROCESSOR'S VIEWPOINT

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At last year's Potato Utilization Conference, I briefly cited data obtained from a 1967 computer study by E. I. DuPont de Nemours and Co., projecting the growth of the processed potato industry. The DuPont study barely missed its projections for 1968, which called for 1.88 billion pounds of frozen potato products to be processed. The figures published in April 1969 by the National Association of Frozen Food Packers, Washington, D. C., (5) reported the 1968 frozen potato pack to be over 1.7 billion pounds.

According to the NAFFP figures, the frozen potato pack has registered an unbroken series of increases each year, first hitting a billion pounds in 1964, and showing a dramatic rise of 16.4 percent in 1968 to reach the 1.7-billion-pound figure. Frozen potato products accounted for 45.0 percent of the total frozen vegetable pack in 1968, up from 41.9 percent in 1967. Potatoes alone are credited by NAFFP with propelling the continual rise in frozen vegetable production.

Now, for some projections as to what we can prepare for in the next few years, let us look briefly at the total DuPont computer data for potato products:

TABLE I.--Estimated production and consumption of processed potato products, 1966-1976 (1)

Year	Production of processed potatoes (Thousands of pounds)	Value at final price	Per capita consumption (Pounds)	U.S. population (Millions)
1966	1,459,633	319,657,000	7.50	180.0
1967	1,662,485	365,745,600	8.35	199.1
1968	1,884,442	414,577,240	9.38	200.9
1969	2,110,160	464,423,520	10.44	202.9
1970	2,362,497	519,749,340	11.53	204.9
1971	2,615,216	513,347,520	12.64	206.9
1972	2,875,640	633,640,080	13.76	209.0
1973	3,139,680	690,729,600	14.88	211.0
1974	3,411,200	750,464,000	16.00	213.2
1975	3,685,494	810,808,086	17.11	215.4
1976	3,962,140	871,670,800	18.20	217.7

What have been some of the factors contributing to this rapid growth? According to a USDA Bulletin published in 1968 (8), away-from-home food service is available in more than 371,000 establishments in this country, not counting elementary and secondary schools, military installations, correctional institutions, in-transit feeding operations, Federal hospitals, and boarding houses. Of this total, nearly 93 percent are public eating places and the others are such institutions as hospitals, colleges, and homes for the aged. Together they have gross sales of about $22 billion a year in food and nonalcoholic beverages. These estimates are based on data collected in 1966 by the U. S. Department of Agriculture and the food industry from representatives of over 6,000 food-service operations.

The study showed that men are the main away-from-home eaters. Alone, or in groups, they were the principal patrons of 49 percent of the public eating places between opening time and 11 a.m., 33 percent between 11 a.m., and 4 p.m., 21 percent between 4 p.m. and 9 p.m., and 22 percent between 9 p.m. and closing time. Family groups were the predominant customers in 17 percent of the eating establishments at the dinner hour (from 4 to 9 p.m.), but there were fewer of them at other times of the day.

Over 100 million consumer transactions took place each day in over 371,000 food-service establishments, according to the 1966 survey. This means that a meal, snack, or nonalcoholic beverage was served to a customer over 100 million times a day. Even though each of these transactions does not represent a different customer, the number of persons served is a substantial proportion of the population. Public eating places served an average of 247 meals, snacks, or beverages daily, and institutions, 684. If the transactions in food-service outlets of the types excluded from the survey were added, the total number for a day would be over 120 million.

Nearly 3.3 million persons worked in food-service outlets. The average for public eating places was eight workers, and for institutions, 22. Less than one-half of the public eating places had been operated by the same proprietor for five years or more. One-fifth of the proprietors had been in business at the same location less than one year. This rapid rate of change in food-service establishments reflects such problems as rising costs and increasing competition.

According to an article published last March in Fast Food (2), there is a very definite trend to franchising, creating, in effect, "the new independents." The 50 food-service franchises listed in the article were only a sampling of the industry. It is truly an eye-opener to see the magnitude of business these organizations do. The first 7 listings are given in Table II.

The number of franchised units and their sales (Table II) begins to tell part of the story as to the very rapid growth of the potato industry.

However, I have been disturbed by Bernie Feinberg's paper given at the last Potato Utilization Conference, "The Grim Battle for a Place in the Market Basket." (3) Have the potato processors lost sales to the very jealous "total food suppliers"? Have we completely searched out the last of the new potato products, or have we become complacent with the success story? Will the

TABLE II.--Some food-service franchises and their sales (2)

Organization	Units				Gross volume (millions of dollars)	
	1968		1969 (est.)		1968	1969 (est.)
	Franchised	Company-owned	Franchised	Company-owned		
A&W International	2400		2420-2430		--	225
Arby's Roast Beef	150	12	360*		3	6
Biff-Burger	43	7	46	14	1.25	2
Bike's	12	20	15	35	2	3.174
Blimpie Base	31		40		0.75	1.5
Burger Chef (General Foods subsidiary)	691	209	830	280	160	210.9
Burger King	370	50	490	87	--	--

*Total.

frozen french-fried-potato processors be bankrupted by the inroads being made by the manufacturers of dehydrated instant french fried potatoes? We heard back in the 'forties and 'fifties that frozen french-fried potatoes would not overtake the fresh. As processors, we heard the potato-chip people claim proudly that they still processed more potatoes into chips than other forms of processed potatoes being made. Of late, we have heard some groans from them as the soap and cereal people have entered the snack markets.

This grim battle Bernie spoke of last year is here today. The substitutes are on the move. We can expect foreign potato processors to be knocking at our doors some day, just as foreign companies have invaded American markets in other industries.

Although the United States is an important potato-growing Nation, it is not the largest, as can be seen from the following USDA statistics on acres in potato production in 1967: (7)

U. S. S. R.	20,586,000	Yugoslavia	815,000
Poland	6,827,000	United Kingdom	708,000
West Germany	1,747,000	Brazil	536,000
East Germany	1,695,000	Japan	452,000
United States	1,458,000	Argentina	403,000
France	1,245,000	Netherlands	341,000
Czechoslovakia	993,000	Austria	331,000
Spain	941,000	Canada	304,000
Italy	838,000		

Who are the users of processed foods? Last year at the Potato Utilization Conference, James Morrell, of Saga Food Service, listed four kinds of kitchens: (4)

1. The institutional kitchen
2. The in-plant kitchen
3. The restaurant kitchen
4. The home kitchen

Mr. Morrell also described food management in kitchens of tomorrow. Without doubt, the potato-processing industry has already entered into research geared for sales to the kitchens of tomorrow. Today, we call them convenience foods. Convenience has been the keyword in the development of new food products. Great advances have been accomplished in:

1. The convenience of purchase and storing
2. The convenience of portion control and cost accounting
3. The convenience of preparation and servings
4. The convenience of cleanup

Convenience foods can be defined as, "prepared foods fabricated to achieve economies of labor and time in usage." However, after the initial thrust into the domain of convenience foods, and after the novelty has dulled somewhat, many of the institutional packers, as well as institutional users, are standing back and considering the possibility that quality may have failed to keep up with convenience.

Quality, in general terms, may be straightforward; but, when speaking in terms of convenience foods, it is not straightforward, and not simple to define. The nutritional value, the flavor, and other sensory characteristics, as well as convenience, must be considered when evaluating convenience foods.

Considering the sensory aspects of food quality (visual appearance, odor-flavor, texture, consistency) we all have a strong feeling for certain convenience foods and against others, based upon each of the sensory attributes. Some foods possess convenience and the sensory quality we readily accept. Others may be convenient, but fall so short of the desired sensory quality as to be totally unacceptable. Regardless of personal judgments and opinions relative to sensory quality, any convenience food product that successfully maintains its position in the market cannot be considered a failure.

We also find gourmet foods with convenience foods, and for this reason, many of the convenience foods are based more often on economical pricing than on technical quality attributes.

The lower quality of convenience foods often results from competitive prices limiting the resultant product rather than technical inability to package quality. Thus, we have two opposing factors that split the convenience packaged food market into two segments:

1. Premium foods packaged with quality that commands a premium price

2. The middle-of-the-road food that is bound to pricing limitations and is destined for those more interested in price than in quality

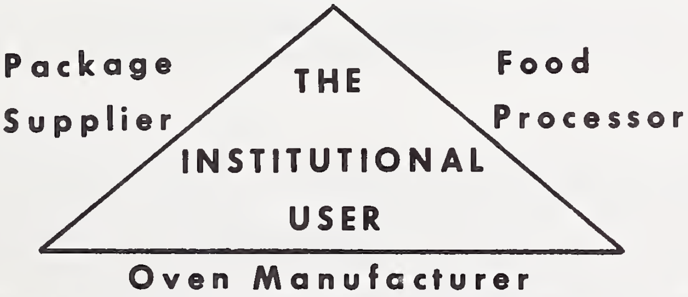
We can expect major advances in food products for the near future, and beyond question convenience will continue to be a major factor in these developments. However, we can also expect significant advances in quality so long as there is sufficient compensation for the products to be profitable. There are enough of these successful products in the market basket to see their economic and technical feasibilities. Many of these convenience foods can truly be classified as gourmet foods at moderate prices.

There are other factors that must be programmed into these evaluations of convenience foods. In many of these convenience foods, the products are not individually wrapped for single-person servings, but are contained as a premeasured mass of food calculated for multiple number of servings in, mainly, a large disposable aluminum serving dish. This dish is used to store prepackaged foods, to cook in, and to serve from. These dishes may contain anywhere from two or three pounds up to 18 or 20 pounds. At this point, it is purposeful to question the convenience of these convenience foods:

1. Just how heavy should these packaged foods be?
2. Just how big should they be?
3. Just how long can be required for cooking before they become inconvenient?
4. What deterioration occurs during preparation and holding to destroy the wholesome features of the food?

Everyone is quick to realize the importance of convenience foods and the vast areas they have opened for development. What started out as portion-controlled foods, with the promise of reductions in operating costs and labor, has left the market far from fulfillment. Is it time to seek out what has happened?

In a recent article on convenience foods, Joseph Ryan (6) has pictured the processor as one side of the following triangle:



To oversimplify Ryan's conclusions, he says food processors must arrive at standard sizes of disposable units and formulate from these sizes. They must take into consideration the ovens that are available to cook the product in, and they must standardize on sizes that can be easily handled and that will minimize product deterioration during preparation and subsequent holding. Of course, all these considerations are directly related to the actual convenience of the total package.

The shallow, half-size (10-3/8 by 12-3/4 by 1-1/2 in.) steam-table pan has a half-gallon capacity and offers the following advantages:

1. Accommodated by the widely accepted module, the 12- by 20-in. steam table insert
2. Shorter reheat time for optimum convenience
3. Less adverse effect on food quality
4. Less waste from leftovers
5. Less fatigue to operators
6. Good structural rigidity after heating; full-size pans tend to bend or spill
7. Greater flexibility and compatibility with a variety of food handling and reheating equipment

How far have convenience foods entered into the realm of institutional feeding? For an answer, here are three examples. At Mount Sinai Hospital in New York, 35 percent of the $1.4-million budget in 1969 is being spent on convenience foods. At St. Mary of Nazareth Hospital in Chicago, convenience foods have been introduced one by one, until 80 percent of all meals served are of the convenience type. Avis Rent-A-Car employee feeding organization in New York reports that 99 percent of the foods it serves are convenience foods.

What other advantages are there in the institutional use of convenience foods? The following are among them:

1. Preheated individual meals, distributed in aluminum containers and reheated in convection ovens on site, make it possible to serve 180 hot lunches in six minutes. The use of canned, frozen, or convenience foods speeds the packaging of lunches in the central kitchen.

2. It was reported in one school system that a convenience food system saved $40,000 in total operating costs. Total labor costs decreased $39,000, which resulted in a drop in labor cost per lunch 14 cents to 7 cents.

3. The Astrodome has converted almost its entire operation to convenience foods because of the speed with which large numbers of people can be fed.

4. In recent demonstrations to the U. S. Air Force, we served the extruded french fry, "Fry-Mix," in 5-ounce portions to as many as 1,500 men in 45 minutes. The operations verified that a convenience product can be served in large volumes at high speeds.

Some of the recent new trends utilize foods that have kicked about for many years. This is the case with the "soul foods." Exotic, gourmet dishes have been gaining popularity in this country over the last several years. Now, apparently, an indigenous food pattern has also gained the "in" designation. Soul food--dishes that have traditionally made up the food patterns of the culturally deprived Southern Negro--are now the chic thing to serve.

What are soul foods? They are, as the Wall Street Journal reported last

November 27, foods scorned by plantation owners in the South as unappetizing leftovers, but eaten mainly by Southern Negroes and poor whites. Chitterlings, pronounced "chitlins," are hog intestines that are boiled and served heavily spiced. Pigs' feet, knuckles, tails, and ears are also part of soul-food cuisine. Other Deep South dishes that qualify as "soul" are black-eyed peas, collard and mustard greens, corn bread, squirrel, and opossum, although the latter hasn't spread to the North. Other foods must be prepared a certain way to qualify. Chicken is soul food if laced with salt, pepper, garlic, and paprika and fried in hot bacon fat. So are pork chops if coated with a mixture of flour, salt, and pepper and fried in a quarter-inch of hot shortening.

Some foods, such as barbecued spareribs, candied yams, fried hominy, baked grits, and stewed corn, are considered plain Southern cooking by some, but others classify them as "soul."

At any rate, such foods are now so popular in the North that demand has caused prices to soar, making some Negroes most unhappy. In Philadelphia, it is reported that a 10-pound container of chitterlings which used to sell for 79 cents now costs $3.99.

There are now soul-food restaurants in New York City and frozen chitterlings are available in the supermarkets in fashionable sections. In Chicago, recently, a program on soul-food preparation was included in a series of demonstrations on various cultural foods put on by the People's Gas and Light Company. Because the expert asked to do the demonstration has customarily cooked by the "pinch-of-this-and-pinch-of-that" method, she had to prepare her meal several times in advance in the company's test kitchens so that the home economists could develop recipes for distribution at the demonstration.

I believe, if we in the processed potato industry take stock of what we are selling, the majority of us will find frozen french fries are our "bread-and-butter" item. But, have we processors encouraged institutional users to use fries in other forms as well? Literally thousands of recipes are available for the asking and searching to promote still further sales into the consumer market.

In closing, I would like to quote an old saying,

> "The surest way to keep
> a customer or a husband
> is not to give him indigestion."

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PROGRESS REPORT ON BULK RAIL SHIPMENTS OF POTATOES

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In 1960, the first conveyorized car for hauling bulk potatoes was introduced by the Bangor and Aroostook Railroad. Toko and Ries (2) reported that the use of bulk cars is basically sound on the basis of labor savings. Weber, Iritani, and Dixon (4) found greater damage in bulk potatoes than in potatoes shipped in sacks. Weaver and Merrill (3) reported that bulk potatoes could be handled faster with one-fourth to one-fifth the personnel required to handle potatoes in sacks. Western Fruit Express has about 700 bulk cars of the standard ice-bunker refrigerator (RS) type and about 150 more will be converted for use in the near future. The load capacity of these cars greatly exceeds that of the sack cars.

Late-crop potatoes are shipped from the Red River Valley in extremely cold weather during part of the shipping season. They may be loaded at -15 to -20 deg. F., and often they arrive at their destination with frost injury. Unless they are protected in transit from these low temperatures, good chipping potatoes may be so affected that they will produce undesirably dark chips. A 1966 report by the Association of American Railroads (1) indicated that loss and damage to potatoes accounted for 17 percent of the losses of fresh fruits and vegetables shipped by rail and that 77 percent of the potato losses were attributed to improper handling and temperature failure.

These studies were undertaken to obtain information on handling losses and temperatures occurring in winter rail shipments of bulk potatoes from the Red River Valley of Minnesota and North Dakota. The studies compared the effects of loading and shipping bulk loads of potatoes in RS cars and in two new types of bulk potato cars with greater load capacities in which temperature was controlled mechanically.

This preliminary report presents part of the results from these test shipments.

Materials and Methods

RS bulk cars used in these tests were equipped with air-circulating fans driven by the wheels when the car is moving. The number of thermostatically controlled heaters used in a car depended on the air temperature in transit. The cars were equipped with floors that sloped at an angle of 12 to 15 degrees toward a draper chain conveyor in the center of the car which extended from the ice bunkers on each end of the car to a cross-conveyor trough at the center of the doorway. Plywood pick-out boards covered the unloading conveyor and cross conveyor trough.

The center-flow Conditionaire (ACF) bulk potato car built by ACF Industries Shipper's Car Line Division is basically a covered hopper car with three compartments (figure 1). Each compartment has a full-length hatch at the top

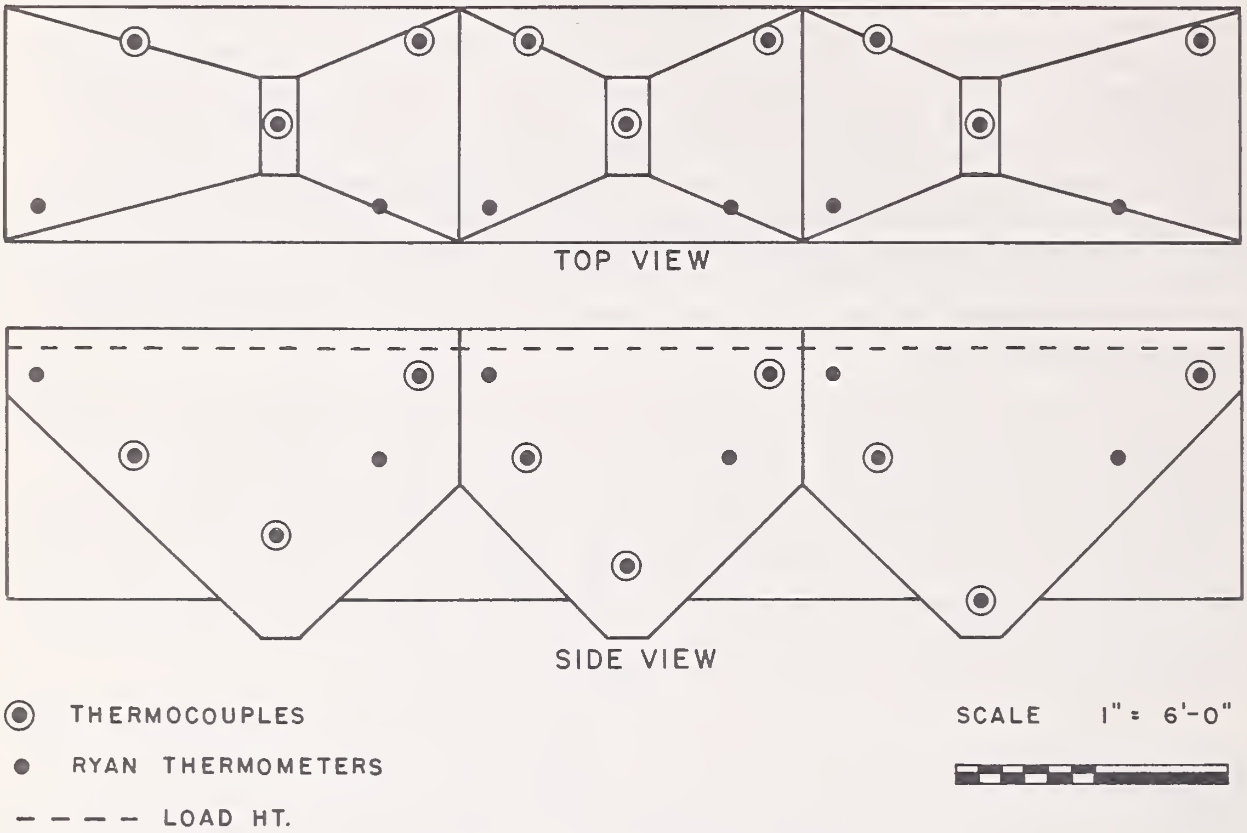

Figure 1. The top and side view of the ACF car showing the location of thermocouples and Ryan thermometers.

and a gravity-flow outlet at the bottom. Sliding-gate outlets open longitudinally, allowing the potatoes to drop onto a conveyor placed underneath. The car's exterior is insulated with two inches of polyurethane foam. A self-contained diesel-electric generator system provides 230 volts to power the heating and cooling equipment. Air forced through the load from ducts opening at the bottom of each compartment is automatically maintained at a set temperature between 30 and 70 deg. F.

The mechanical refrigerator car used in these tests was converted for bulk shipping of potatoes by removing the floor racks and building in a slatted floor which sloped toward a draper chain conveyor extending from each end of the car to a cross-conveyor trough in the doorway. The walls, ceiling, and floor are surrounded by a plenum and have a 6-inch insulation core for forced-air circulation. Side-wall ducts and air diffusers in the ceiling aid in air circulation. A diesel-electric generator system provides 220 volts to automatically power the heating and cooling equipment as required to hold the desired thermostat setting. A 5-stage control provides a high and low setting each for heating and cooling and an intermediate setting when only air circulation is required. Temperature can be controlled between 0 and 70 deg. F.

A sampling procedure was devised whereby 200 tubers per 600-cwt. load in the RS bulk car, 400 tubers per 1200-cwt. load in the mechanical bulk car, and 600 tubers per 1800-cwt. load in the ACF car were taken at random from the loading and unloading conveyors. Tubers were removed at intervals which depended on the time involved in loading or unloading the test cars.

Bruising was determined by using a catechol solution (30 gm. of pyrocatechol per gallon of water). Every fifth tuber from each sample was immersed in this solution for 10 minutes, then allowed to dry before rating for bruising. Injured areas turned dark red to black after being dipped in the catechol solution. This discoloration occurred in any fresh injury in which the periderm was broken. The catechol-treated tubers were rated as follows: slight, less than 5 percent of the surface damaged; moderate, 5 to 10 percent of the surface damaged; and severe, more than 10 percent of the surface damaged. Tuber temperature at loading and unloading was measured with a Taylor pulp thermometer in 10 to 20 tubers taken at random from the loading and unloading conveyors.

The remainder of each random sample (160, 320, or 480 tubers) was used to determine the incidence of fusarium dry rot, bacterial soft rot, black spot, and hollow heart at loading and unloading.

Chip quality as expressed by color was determined from random samples of 15 to 20 tubers from the loading and unloading conveyor for the RS bulk car, from each compartment for the ACF car, and from each end of the mechanical refrigerator car. Chip color was determined with an Agtron colorimeter.

To load the RS bulk car, potatoes were carried from the grading table by conveyors to a telescoping loading conveyor at the door of the car. The conveyor could be extended into the car and directed toward either end and lowered and raised hydraulically. Filling began in one end of the car with the conveyor lowered to within 6 inches of the floor. As the car filled, the conveyor was raised and directed from one side of the car to the other and gradually retracted to give a uniform fill. When one end of the car was filled, the conveyor was directed to the other end and the filling process was repeated. The center of the car was filled last as the conveyor was backed out the door.

The mechanical car was loaded by the same method used in loading the RS car. However, the conventional loading conveyor did not reach the ends of the car and various types of chutes were devised to convey the potatoes to these areas.

When unloading the RS and mechanical cars, the doors were opened and a conveyor was moved into position in the cross-conveyor trough. The end pickout board was removed from over the cross conveyor to start the flow of potatoes. The potatoes were conveyed to a pallet box loader which was raised electronically as the pallet boxes filled.

To load the ACF car, potatoes were conveyed from the grading table to a conveyor extending out of the storage and over the car. The potatoes were directed onto a hydraulically controlled telescoping conveyor which was lowered through the hatch to the bottom of the compartment. As loading progressed the conveyor was elevated. When loading was completed the elevator was removed, the hatch closed, and the car moved to position the conveyor over the next compartment.

At unloading, the insulated gate cover was unlatched and swung to one side. A belt conveyor was moved into position between the track and the gate. A capstan was swung out, locked into position, and turned with an iron bar to open the sliding gate. The potatoes were conveyed to a pallet-box loader and loaded into pallet boxes.

Ryan recording thermometer locations in the RS car are shown in figure 2. The Ryan for recording ambient temperatures was located underneath the car fastened to the air brake cylinder bracket.

In the ACF and mechanical cars, Ryan thermometers and a Honeywell Brown Electronik 24-point thermocouple recorder were used to record ambient and transit temperatures. The location of Ryan thermometers and thermocouples in the ACF car were shown in figure 1, while figure 3 shows the location of these sensors in the mechanical car.

Results

Temperatures of winter shipments of potatoes from the Red River Valley are shown in Table I. In test No. 1, where the in-transit temperatures in the cars varied by 10 to 12 deg. F., the highest temperatures were recorded in the top quarter of the load near the bunker containing the alcohol heaters. The lowest temperature was in the bottom quarter of the load near the door, indicating that air circulation was inadequate. In the other tests where the temperature variations were as much as 10 deg. F., lowest temperatures were also noted in the bottom quarter of the load near the door. In test No. 5, inspection revealed frozen potatoes in Car No. WFBX-71568, and the car was held for 3 weeks to allow the frozen tubers to deteriorate.

At loading, chipping potatoes averaged 9 percent dry rot and 6 percent black spot. At unloading, these percentages were 10 and 7, respectively.

In general, chips made from the potatoes at the time of loading were darker than those made from the potatoes after arriving at their destination. Agtron readings for chips made from the potatoes at loading ranged from 50.0 to 52.5 (average 50.6), and at unloading from 47.0 to 59.0 (average 54.0). One RS carload of potatoes made darker chips at destination than at loading. This exception could not be accounted for by a decrease in the temperature within the car as recorded by the Ryan thermometers. Potatoes from other RS cars in these tests produced darker chips than potatoes from the cars in which temperatures were mechanically controlled. At destination potatoes from the ACF car produced chips with a color intensity of about 11.5 percent lighter than potatoes from the RS car. Potatoes from the mechanical car produced chips with a color intensity 3.2 percent lighter than potatoes from the RS car. Possibly the use of alcohol heaters in the RS car without sufficient ventilation produces a physiological change in the tuber causing it to chip darker.

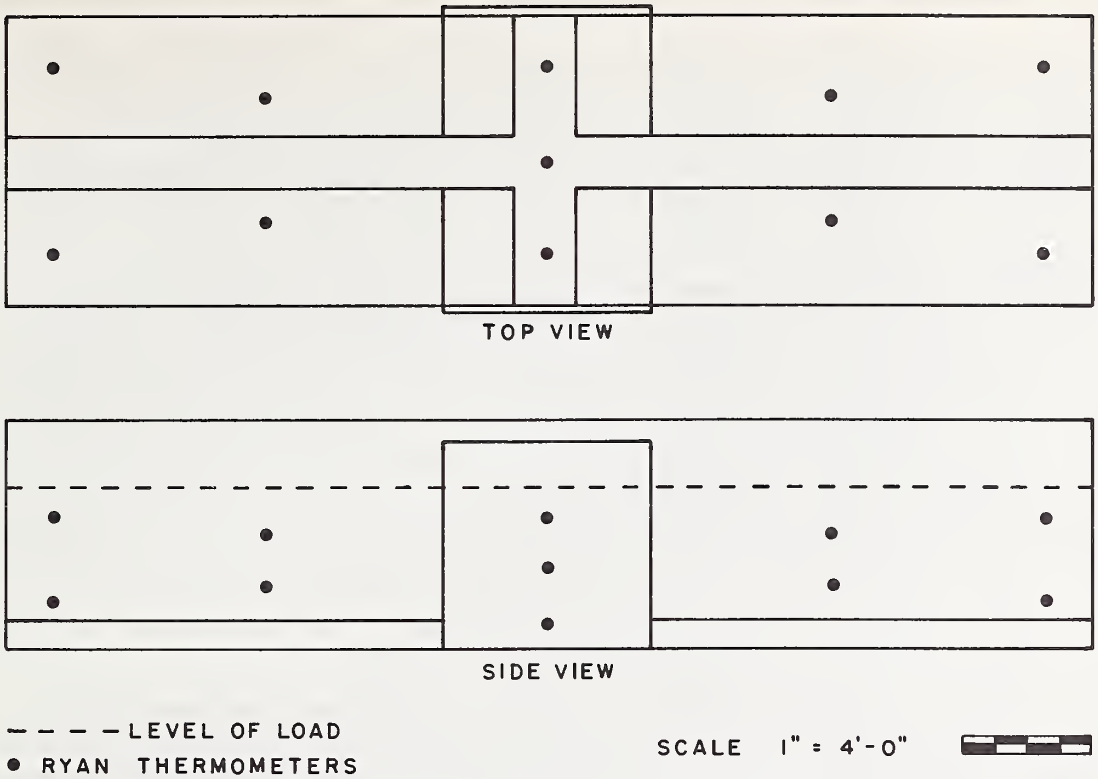

Figure 2. The top and side view of the RS car, showing the location of the Ryan thermometers.

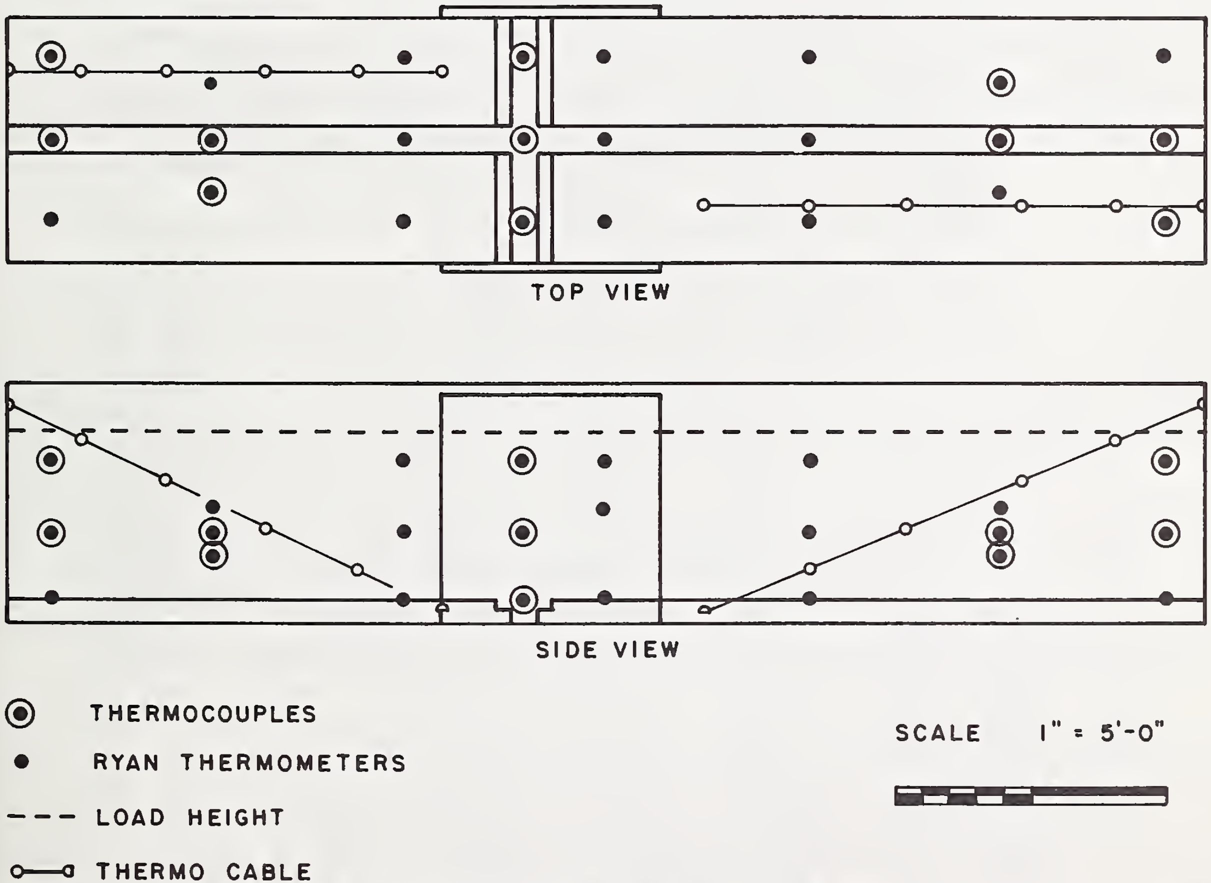

Figure 3. The top and side view of the mechanical car, showing the location of Ryan thermometers and thermocouples.

TABLE I.--Temperatures of bulk shipments of late-crop potatoes from the Red River Valley (January 8 to March 6, 1969)

Test No.	Date shipped	Car		Destination	Outside air temperature (deg. F.)			Temperature inside car in transit (deg. F.)		Avg. tuber temperature (deg. F.)	
		No.	Type		Avg. at loading	In transit		Thermostat setting	Temperature range	At loading	At unloading
						Range	Avg.				
1 (Chip stock)	Jan. 8	WFBX-71720	RS	River Grove, Ill.	4	-2 to 32	11	60	58 to 68	66	60
	Jan. 9	WFBX-71724	RS		-10		9		58 to 70	64	60
2 (Chip stock)	Jan. 14	NP-419903	ACF	Dallas, Tex.	24	14 to 42	26	60	58 to 63	57	61
	Jan. 15	NP-93010	RS		28		27		62 to 67	58	62
3 (Chip stock)	Mar. 6	WCFX-8765	Mech.	San Jose, Calif.	11	-1 to 50	25	60	58 to 66	51	60
	Mar. 6	WFBX-71954	RS		9		24		54 to 64	50	60
4 (Table stock)	Jan. 14	WFBX-73100	RS	Garland, Tex.	28	14 to 42	31	40	35 to 45	39	48
5 (Table stock)	Feb. 8	WFBX-71568	RS	Burlington, Iowa	- 8	-4 to 30	14	40	33 to 45	42	56
	Feb. 8	WFBX-71746	RS		- 8		14		33 to 47	43	46

Further work is needed to determine the factors causing this condition.

Table-stock potatoes averaged 6 percent dry rot and 3 percent black spot at loading, and these averages were 10 and 6 percent, respectively, at unloading.

Bruising was serious while potatoes were being handled during loading and unloading. Severe bruising averaged 19 percent at loading and 10 percent at unloading. Moderate bruising averaged 12 percent at loading and 13 percent at unloading. Slight bruising averaged 23 percent at loading and 13 percent at unloading. This bruising was not accumulative because the catechol is effective only on freshly damaged tubers before suberization begins. The bruising involved was that which occurred during loading and later that which occurred during unloading. Methods of handling used at loading were responsible for the higher rate of injury. Part of the decay losses in transit and the grade defects and culls found during terminal packing operations were attributed to the tuber damage that occurred during loading and unloading.

Acknowledgments

The author acknowledges the participation in these studies of the following individuals and organizations: ACF Industries; Great Northern Railway; Northern Pacific Railway; Frito Lay, Inc.; Morton Foods, Inc.; Guys Foods, Inc.; Safeway Foods, Inc.; Rutherford Potato Co.; The Burlington Railway; The Missouri Kansas and Texas Railway; The Atchison, Topeka and Santa Fe Railway; The Southern Pacific Railway; The Spokane Portland and Seattle Railway; R. W. Penney, Mechanical Engineer, Market Quality Research Division, Beltsville, Md.; L. Beraha, Plant Pathologist, Market Quality Research Division, Chicago, Ill.; and L. A. Schaper, Agricultural Engineer, Transportation and Facilities Research Division, East Grand Forks, Minn.

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COSTS OF TREATING POTATO PROCESSING WASTE

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Introduction

Since the first half of the 1960's many treatment systems for screening and settling potato processing waste water have been constructed, but to date few systems have been provided for more complete treatment. The need for added treatment has been recognized throughout the Nation. Work is rapidly progressing in Idaho to develop accurate design criteria for promising secondary treatment systems that have not previously been applied to potato processing waste water.

The units used for settling and some of the units that will be used for secondary treatment are similar to those used for treatment of other industrial effluents and domestic waste waters.

Costs given in this paper are based on the costs of systems constructed in Idaho, eastern Washington, and eastern Oregon. The costs indicated for domestic systems are taken from a recent article by Dr. Robert Smith, chief of operations research, Cincinnati Water Research Laboratory, Advanced Waste Treatment Branch, Cincinnati, Ohio.*

The costs presented are averages, and may be used for general guidance, but should not be used for financial planning for individual industries without considering current local prices, local site conditions, and waste water characteristics. Costs for systems with a design capacity of 0.5 to 4.0 million gallons per day (mgd) of waste water flow are shown on the following figures. All but a few plants in the U. S. should fall within this range.

Potato Processing

From a waste treatment standpoint, potato processing can be broken into three broad areas in which waste water is produced. These are: (1) initial wash and silt removal, (2) peeling, and (3) processing. Figure 1 is a simplified presentation of potato processing and includes the probable quantities of waste water from a processing plant which has a raw intake of 500,000 pounds of potatoes per day and which exercises a reasonable amount of in-plant waste control. The quantities are based on potato processing in the Pacific Northwest.

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* _Journal of the Water Pollution Control Federation_, _40_(9): 1546, September 1968.

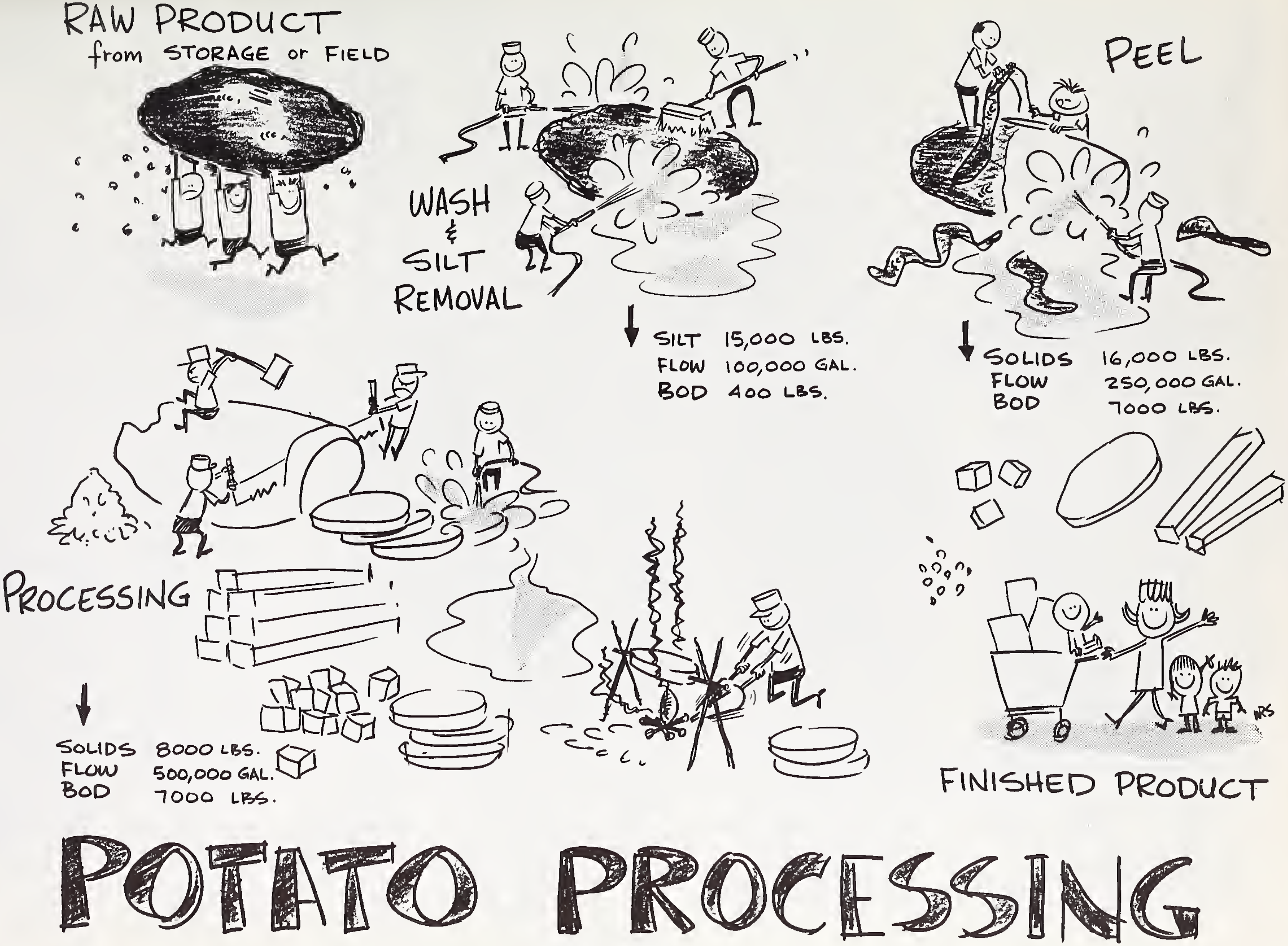

RAW PRODUCT
from STORAGE or FIELD
WASH & SILT REMOVAL
SILT 15,000 LBS.
FLOW 100,000 GAL.
BOD 400 LBS.
PEEL
SOLIDS 16,000 LBS.
FLOW 250,000 GAL.
BOD 7000 LBS.
PROCESSING
SOLIDS 8000 LBS.
FLOW 500,000 GAL.
BOD 7000 LBS.
FINISHED PRODUCT
WRS
POTATO PROCESSING

FIGURE 1

FIGURE 2
UNIT PROCESS SEQUENCE

Treatment Catagory	In-plant	Pre-treat	Primary Treatment	Secondary Treatment	Advanced Treatment
Unit Processes	Conservation & reuse of water Process revisions Process control New products	Screening	Sedimentation Settling ponds	Trickling filters Activated sludge Stabilization ponds Anaerobic filters Anaerobic contact Anaerobic ponds Aerated ponds	Chemical treatment Carbon treatment Filtration Ion exchange Reverse osmosis Air Stripping
			Irrigation		

Unit Sequence

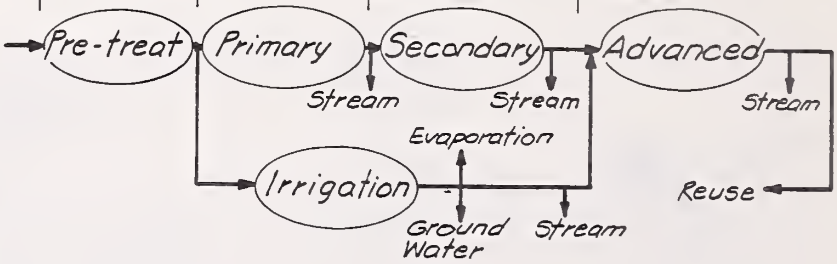
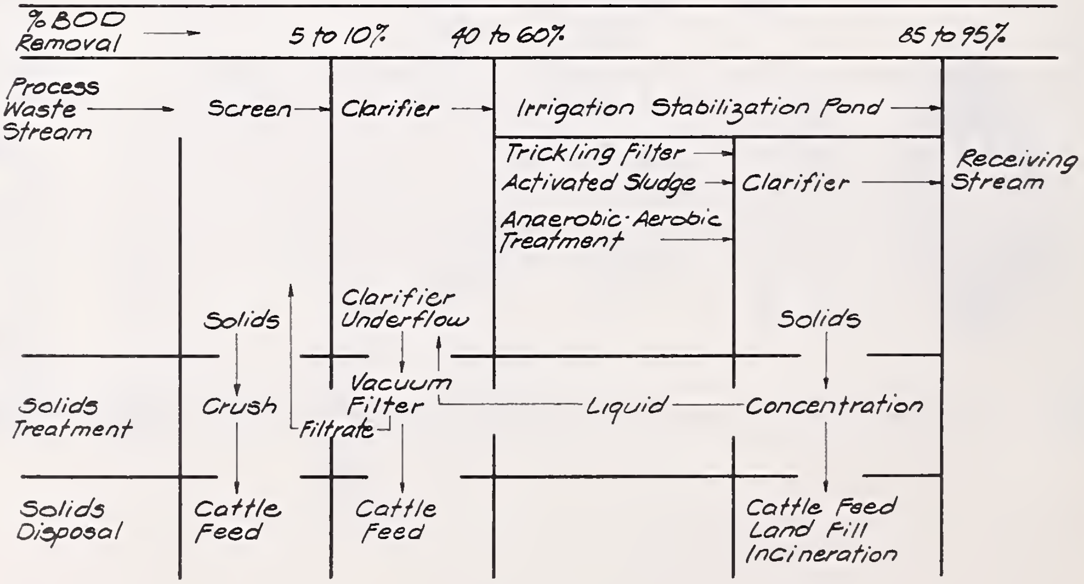


FIGURE 3
POTATO PROCESSING
EFFLUENT TREATMENT



Treatment Systems

The unit processes used in waste water treatment are known by specific names. Those which have the most liklihood of being applied to potato processing waste water are given in the body of figure 2. These unit processes are in turn classified into broad categories of in-plant control, pretreatment, primary treatment, secondary treatment, and advanced treatment. These categories, and the most likely sequential arrangement of the processes, are also shown in figure 2. In general, processes of primary treatment and those preceding it are based on physical removal of solids in suspension, while secondary treatment and advanced treatment methods are based on biological or chemical removal of pollutants.

The number of treatment units used is normally dictated by the amount of pollution which must be removed from the waste stream and the effectiveness of the treatment units. The most universal measure of pollution is biochemical oxygen demand (BOD), a measure of the amount of oxygen required by aerobic bacteria when using the pollution materials as a food source. BOD can be thought of as a measure of the pollution potential of a waste. The removal of BOD by a treatment process is a measure of its effectiveness in separating pollutants from the waste water flow before it is discharged to a receiving stream.

A sequence of treatment steps for the liquid and solid components of processing wastes is shown in figure 3. This figure also indicates the probable range of pollution removal efficiencies for the various treatment steps. The efficiencies shown in figure 3 are accumulative. Primary treatment of potato processing waste water removes from 40 percent to 60 percent of the BOD. By comparison, primary treatment of domestic waste water removes only 30 percent to 40 percent of the BOD. The overall efficiencies, however, of primary plus secondary treatment of potato processing waste water are comparable to the overall efficiencies of primary and secondary treatment of domestic waste water.

Silt water is settled separately from peeling and process wastes so that the solids reclaimed from the process waste water can be used as cattle feed. Treatment processes for silt water are shown in figure 4.

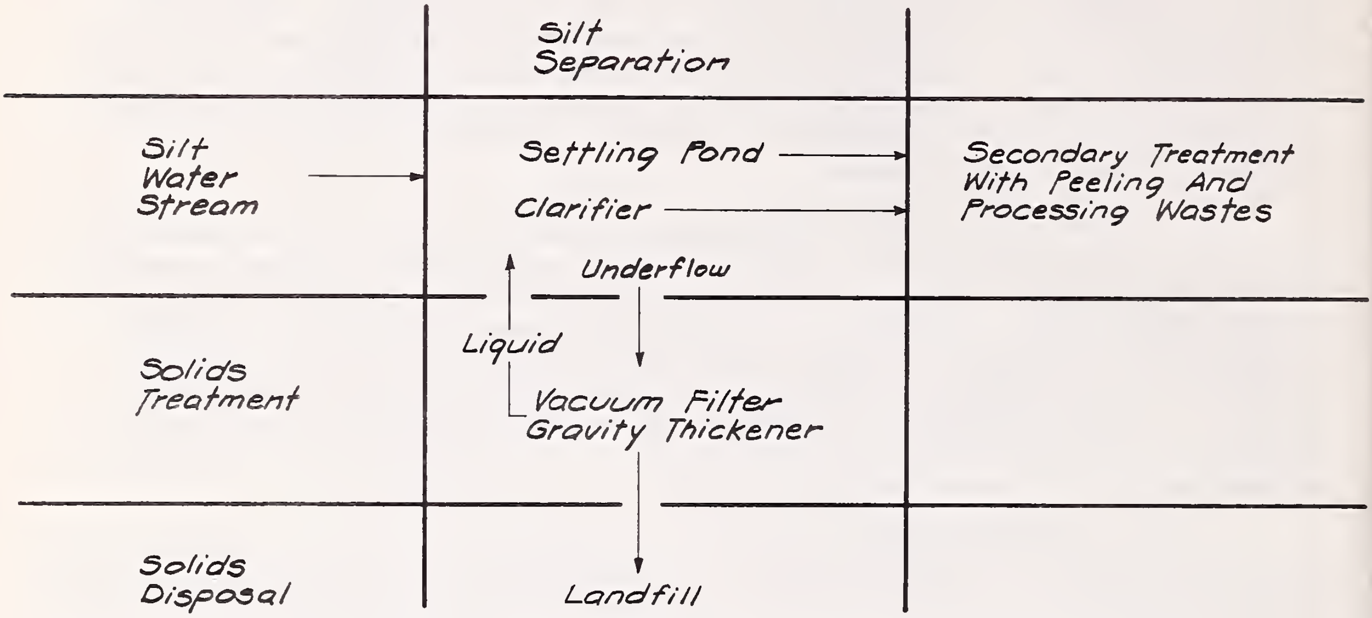
Treatment Costs

The costs presented in the following figures are based on projects in the Pacific Northwest. The costs for primary treatment are based on systems which have been designed and constructed. The costs for secondary treatment are based on engineering estimates which have been made for demonstration projects and preliminary estimates based on pilot plant systems studied by the Potato Processors of Idaho Association.

Because of the rapid change in construction costs, all figures have been adjusted to a common base of June 1967 by using the Engineering News Record building cost index. This is the same reference point in time which was used by Robert Smith in his article on costs for treatment of domestic wastes. It

FIGURE 4

SILT WATER TREATMENT



is important to recognize that building costs are increasing very rapidly. Figure 5 is a presentation of the history of the building cost index and a projection of the index into the future. Estimates of cost increases for treatment systems should be based on the building cost index rather than the construction cost index because the components of labor and materials included in the building cost index have increased at a comparable rate to the cost of treatment systems.

The costs presented include engineering and the contractor's overhead and profit.

Silt Removal

Figure 6 is a presentation of the capital costs for mechanical silt removal. The costs are based on the use of a mechanically-cleaned clarifier, and include solids pumps, electrical gear, piping, and a building to house pumps and electrical gear. It is assumed that this unit would be adjacent to and integral with either primary or secondary treatment units.

In some plants, silt removal can be accomplished by passing the flow through a simple settling pond, the cost for which would depend on the soil's characteristics and the site terrain. But since the cost is relatively minor, this type of silt removal is not given further consideration here.

FIGURE 5

ENGINEERING NEWS RECORD COST INDEX

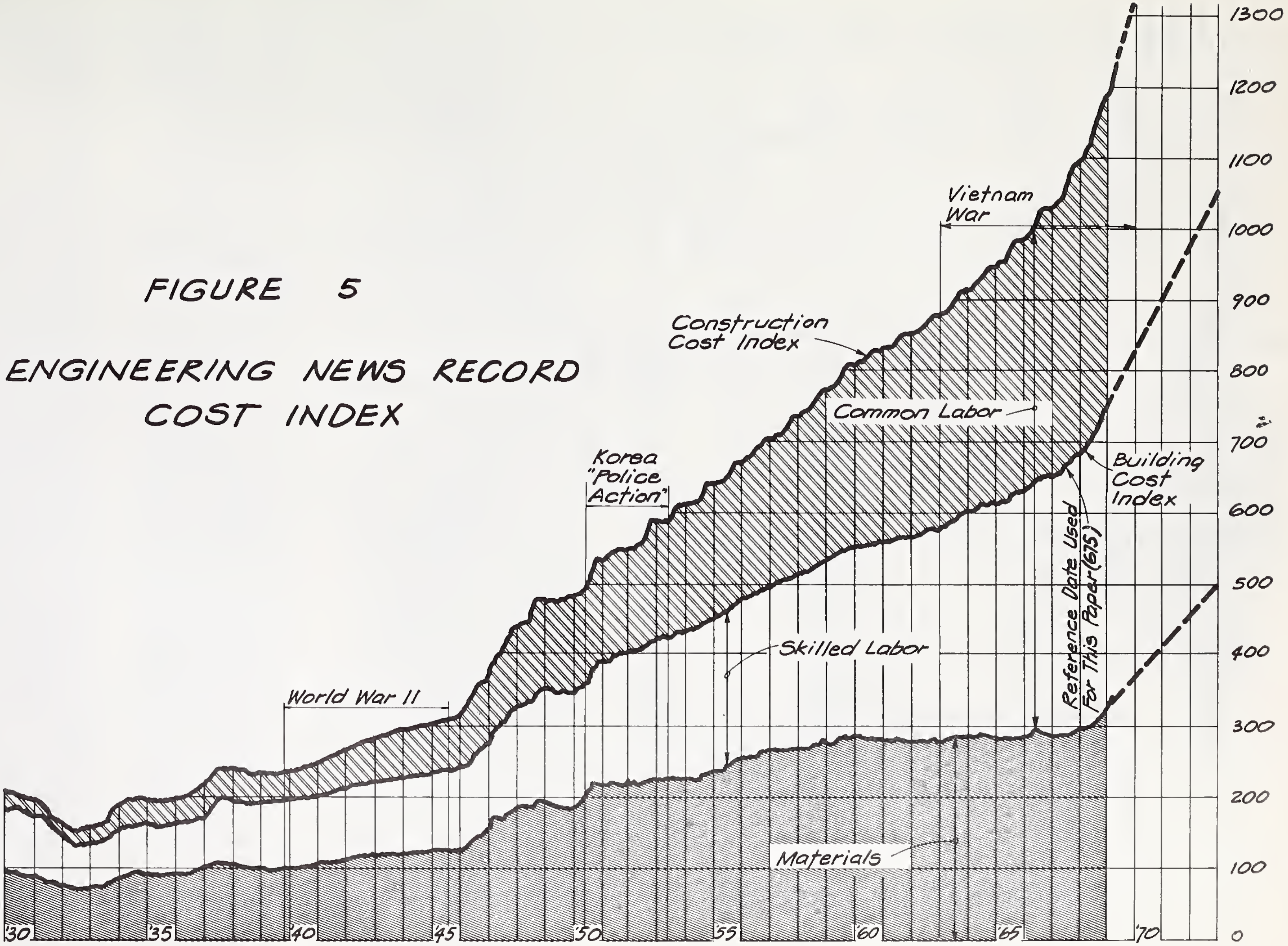
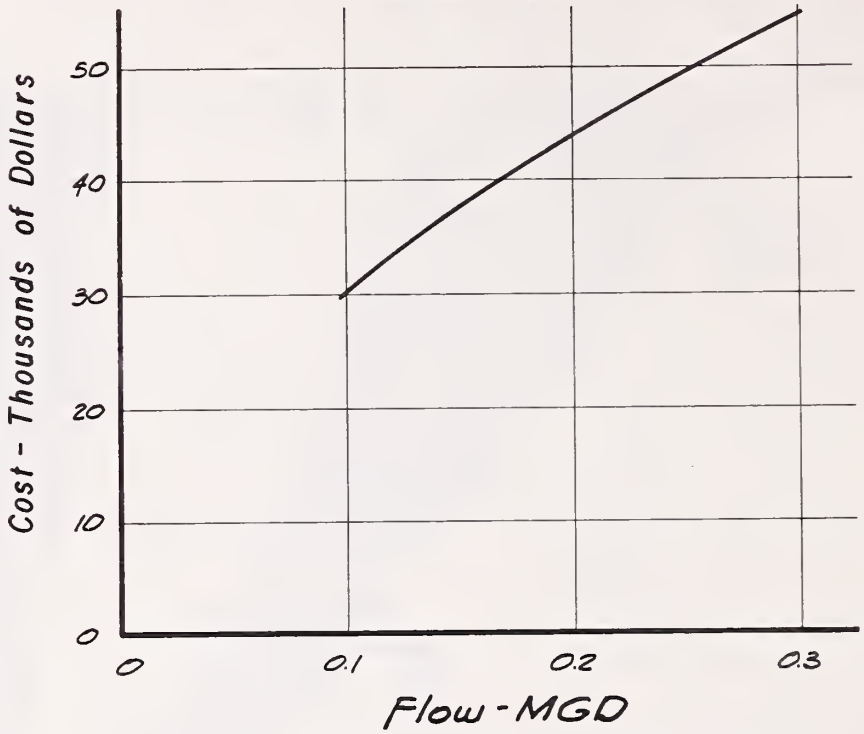


FIGURE 6

MECHANICAL SILT REMOVAL
CAPITAL COST
JUNE 1967



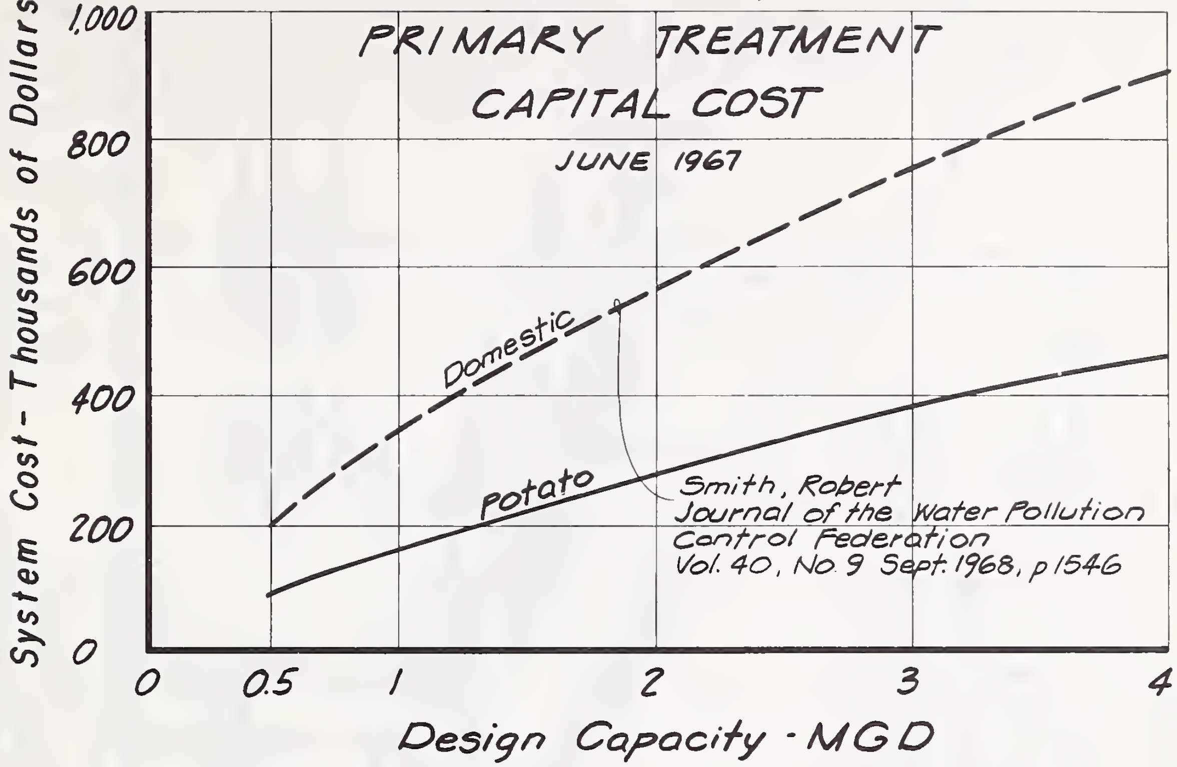
The type of silt removal system used will substantially influence the cost for ultimate disposal of the separated silt. No attempt has been made to evaluate these differences since specific cases vary greatly. In most areas, it is now required that the liquid overflow from a silt removal system be treated in a secondary treatment unit. This can be done jointly with the treatment of peeling and process waste water.

Primary Treatment

The capital costs for primary treatment are shown in figure 7. The costs include screens, clarifier, solids pumps, vacuum filter, solids bin, flow measurement, and a building to house the pumps, screen, vacuum filter, and electrical gear. It does not include a pump station to lift the flow from the processing plant to the treatment plant. The costs are substantially less than the costs for primary treatment of domestic waste water. The reasons for this are:

1. A domestic treatment plant must normally stand by itself separate from any other plant facilities. Therefore, the domestic system includes a testing laboratory, maintenance shops, garage, shower facilities, lunchroom, substantial landscaping, separate water and electrical systems, etc.

FIGURE 7



PRIMARY TREATMENT CAPITAL COST

JUNE 1967

Smith, Robert
Journal of the Water Pollution Control Federation
Vol. 40, No 9 Sept. 1968, p 1546

2. A substantial cost within the primary treatment plants for domestic waste water results from the fact that the separated solids have little value and must be given substantial treatment so that they can be disposed of without causing a health hazard or nuisance.

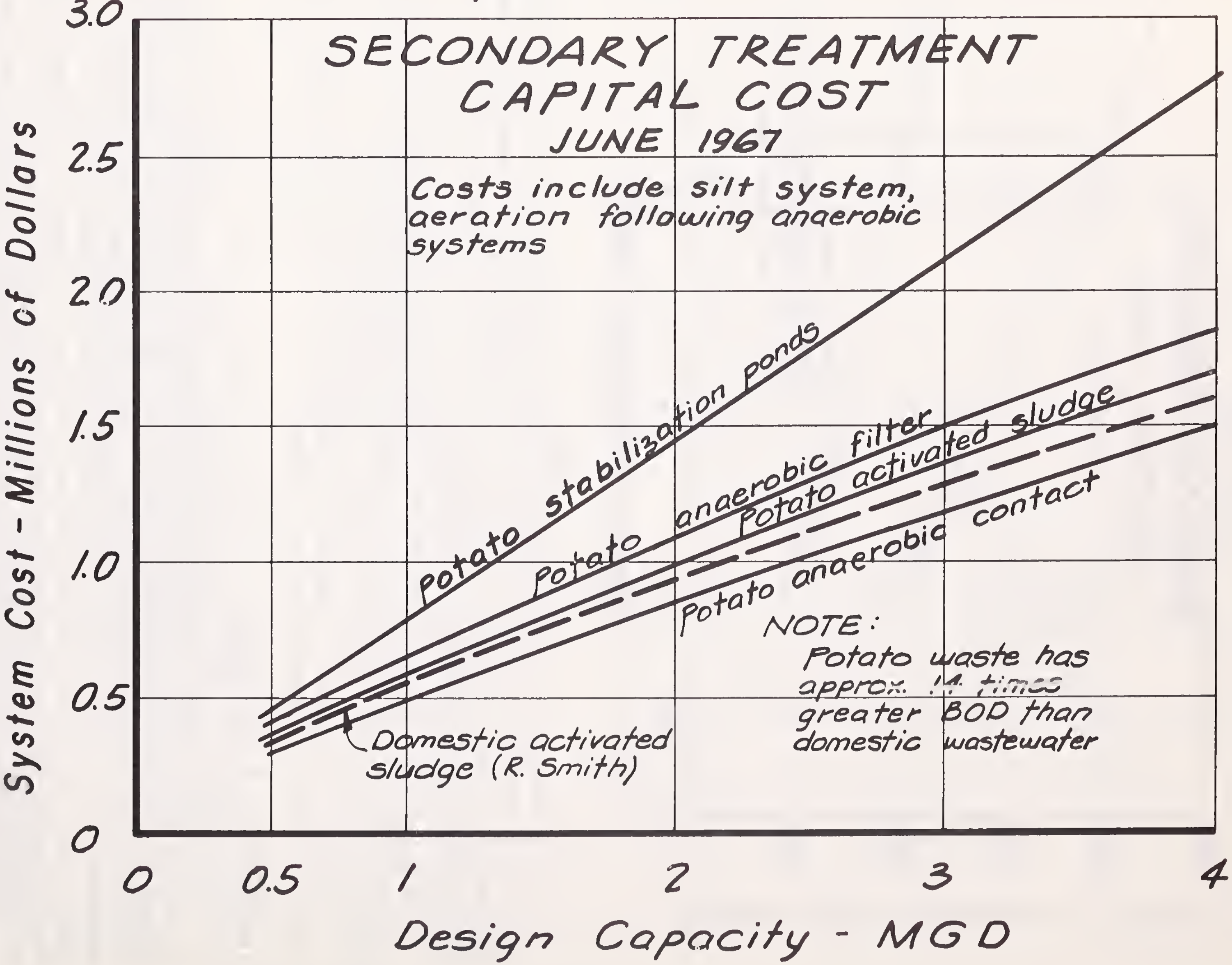
A plant for potato waste water treatment is normally adjacent to the processing plant and is supported by many existing facilities.

Solids from primary treatment of potato waste water do not require a major capital expense for separation and disposal.

Secondary Treatment

The capital costs for secondary treatment are shown in figure 8. With the exception of stabilization ponds, the cost of secondary treatment processes for potato waste water are comparable to the cost of secondary treatment for domestic waste water. The costs shown include primary treatment and solids treatment. In the case of secondary treatment, a major portion of the cost results from the total BOD load and not the flow. A domestic treatment plant for a flow of 1-1/4 million gallons per day would be treating a total BOD load of approximately 2,000 pounds per day, while the potato processing treatment system for the same flow would be treating a total BOD load of approximately 28,000 pounds per day. In terms of the amount of pollutant removed, the secondary treatment facility for a potato processing plant is much less costly per unit of capacity than a domestic treatment facility.

FIGURE 8

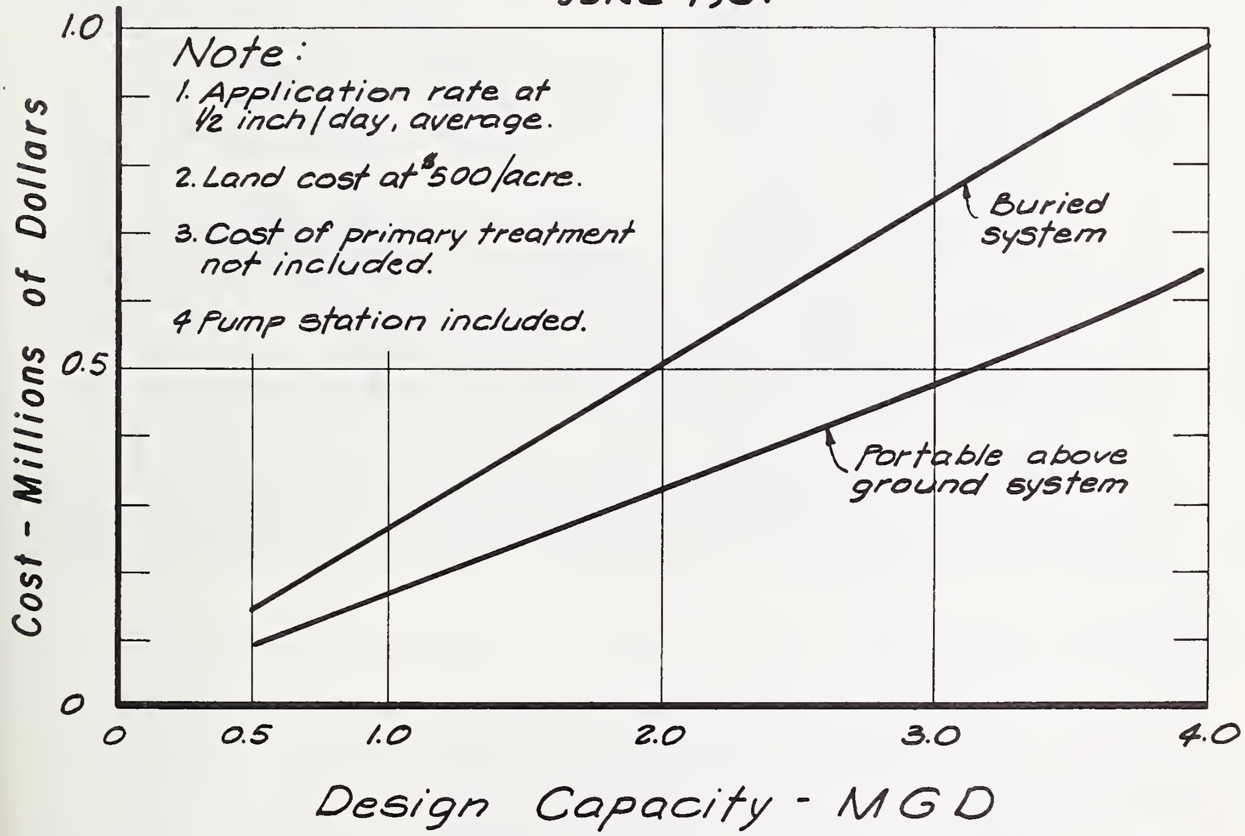

SECONDARY TREATMENT
CAPITAL COST
JUNE 1967
Costs include silt system, aeration following anaerobic systems
Potato stabilization ponds
Potato anaerobic filter
Potato activated sludge
Potato anaerobic contact
Domestic activated sludge (R. Smith)
NOTE:
Potato waste has approx. 14 times greater BOD than domestic wastewater
System Cost - Millions of Dollars
3.0
2.5
2.0
1.5
1.0
0.5
0
Design Capacity - MGD
0
0.5
1
2
3
4

In this presentation it is assumed that the cost of property for stabilization ponds would be $500 per acre, that the cost for construction would be about $2,000 per acre, and that the stabilization pond would be loaded at approximately 50 pounds of BOD per acre per day. The costs shown include a primary treatment system preceding the pond.

Irrigation

The costs for irrigation systems are shown in figure 9. The costs include a pump station, a self-cleaning screen, and a solids grinder. An allowance of $500 per acre for land has been made.

FIGURE 9
DISPOSAL BY SPRAY IRRIGATION
CAPITAL COST
JUNE 1967



The costs do not include primary treatment which would precede irrigation. The cost of buried irrigation systems is based on the assumption that the distribution headers would be steel and that the laterals and risers would be plastic pipe. The above-ground systems assume a buried steel header system and aluminum laterals and risers. Allowance has been made for adequate pipe to cover the entire area so that labor would not be necessary to move the pipes except to harvest the crop. An average application rate of 1/2 inch per day has been assumed.

The irrigation systems on which these costs were based are applying canning waste water through single 3/8-inch nozzles spaced on an 80 by 100 grid with a nozzle pressure of approximately 80 psi. The application rate under these conditions is between 0.3 and 0.4 inch per hour.

Operation and Maintenance Costs

The operation and maintenance costs for primary and secondary treatment systems are presented in figure 10. These costs make no allowance for the return from the sale of the reclaimed solids.

The cost for operating a primary treatment plant, treating potato processing waste water, has been estimated to be greater than the cost for a domestic treatment plant. The major reason for this is that a primary treatment plant for potato processing waste water recovers substantial amounts of solids, which in most cases necessitates the presence of an operator on a continuous basis to control the flow and disposition of these solids. The vacuum filter in most processing plants operates continuously and also results in an operating and maintenance cost.

When considered on a flow basis, the cost for providing secondary treatment to potato processing waste water is much greater than the cost for providing treatment to domestic waste water. In the case of the activated sludge plant, a major reason for this difference is that a substantially greater amount of power is required in treatment of potato processing waste water because of its high strength. The higher cost in the case of the anaerobic contact process is also associated with the greater waste water strength.

The costs given are based on very limited field information and are, for the most part, estimates. Operating and maintenance costs vary more widely than construction costs and should be applied with great caution to specific situations.

Stabilization Ponds

The capital costs for stabilization ponds are presented in figure 11. The costs given in this figure are based on construction costs for municipal treatment ponds. The curve does not include an allowance for land costs but does include engineering.

Because of the high strength of potato processing waste water, the area required for stabilization ponds is normally too extensive to make this system practical.

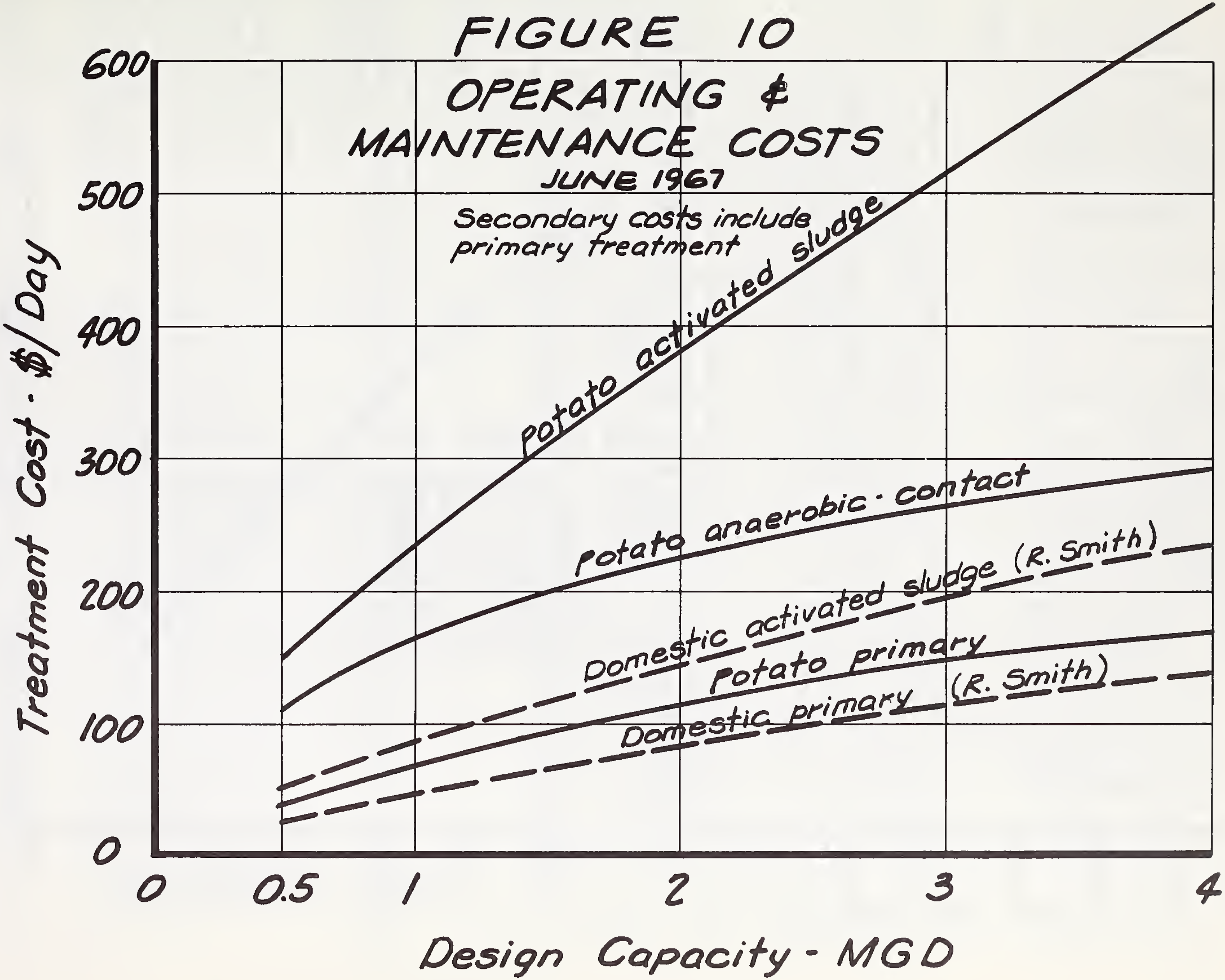
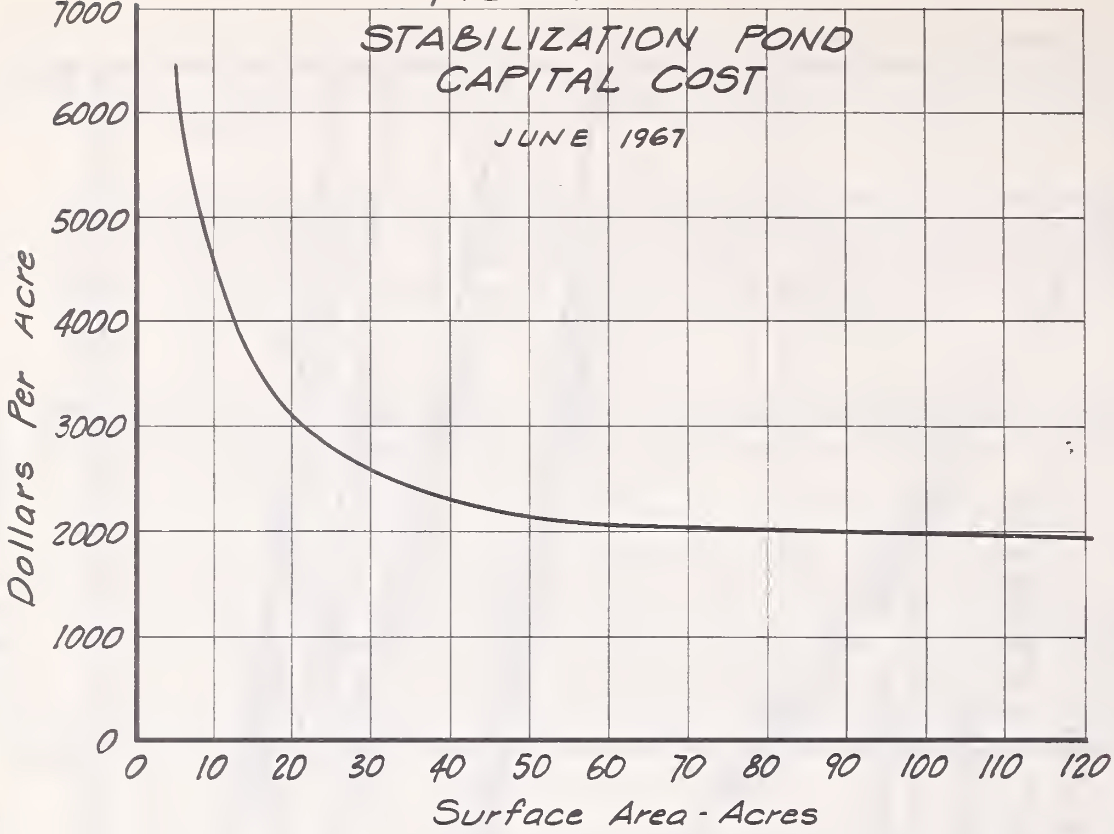


FIGURE 10

OPERATING & MAINTENANCE COSTS
JUNE 1967

Secondary costs include primary treatment

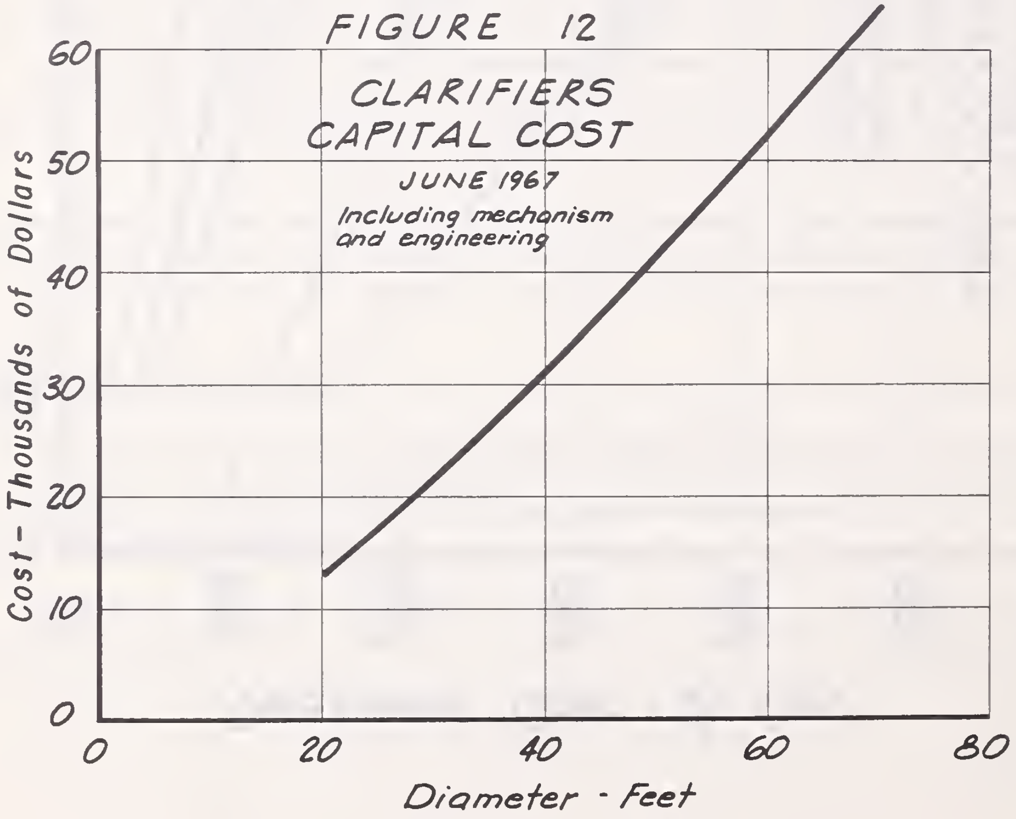
FIGURE 11



STABILIZATION POND CAPITAL COST

JUNE 1967

FIGURE 12



CLARIFIERS CAPITAL COST

JUNE 1967

Including mechanism and engineering

Clarifiers

The cost for clarifiers is shown in figure 12. These costs include the clarifier mechanism and an allowance for engineering. In addition, the estimated costs include the entire clarifier structure, the influent piping within or under the structure, the solids piping under the structure, and foundation gravel. The costs allow for a concrete base slab approximately 6 inches thick and for normal excavation in which the clarifiers are set approximately 4 feet into the ground. The costs do not allow for unusual foundation problems which would result in the use of piling or other special support systems.

Solids

A major cost associated with any treatment system is the disposal of solids. Solids reclaimed in primary treatment are used as cattle feed and help defray treatment costs. It can be assumed that the cost of disposal for solids from secondary treatment of potato processing waste water will be no greater than for solids from a domestic secondary treatment system. It is hoped, however, that through additional pilot-plant work more economical disposal systems for secondary solids, or methods of reclaiming secondary solids, can be found.

The solids separated or created during waste treatment must be disposed of without creating an additional nuisance. Silt can be used as land fill but cannot normally be returned to potato fields because of possible spread of disease. Screenings as well as solids separated in primary treatment are used as cattle feed. After concentration, solids from secondary treatment can be used as land fill, destroyed by incineration, or perhaps used as a feed. Very little as yet has been done on disposal of secondary solids from potato-processing waste water, but it can be assumed that approaches similar to those which have successfully been applied to the treatment of other organic wastes can be used.

Example

The following example will illustrate how to use the cost information presented. Assume the following system will be built in mid-1972. The building cost index for June 1967 was 675 and the estimating cost index in 1972 will be 1,000. The ratio of increased costs is then 1,000/675 = 1.48.

Assume that the system consists of primary treatment plus activated sludge and that the flow is 2 mgd. Assume that the silt water flow would be 0.2 mgd. The cost of the silt system (figure 6) would be $44,000 x 1.48 = $65,000. The cost of the activated sludge system including primary treatment (figure 8) would be $1,000,000 x 1.48 = $1,480,000. The total construction cost for the project in 1972 would then be $1,545,000. The primary treatment portion of this project (figure 7) would be $280,000 x 1.48 = $413,000. The 60-foot diameter primary clarifier (figure 12) would cost approximately $54,000 x 1.48 = $80,000.

From figure 10 it can be estimated that the operating cost would approach $400 per day without any allowance for return from sale of byproducts.

Conclusions

Cost estimates based on the preceding figures should be used only in very broad planning and should be considered only as averages. Planning for an individual project should be based on engineering layouts and specific cost estimates to avoid inaccurate financial planning.

Several general observations can be made about costs of waste treatment. The costs are substantial and they are increasing rapidly. Efforts should be continued to develop new processes or to improve old processes and to reduce waste flow and solids loss in processing. The method of solids disposal will have a pronounced effect on the net treatment cost. Some financial redress may result from grants, tax relief, or joint treatment with municipalities or other industries.

PROGRESS REPORT ON STARCH FACTORY WASTE TREATMENT

(Summary)

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The problem of stream pollution by waste effluents from food processing plants has become one of major importance in the United States. The potato starch industry contributes considerably to this problem. Work is underway to aid the industry by recovering salable byproducts from this waste and reducing stream pollution. The treatment process as proposed would consist of five steps: (1) concentration of dilute waste by reverse osmosis; (2) precipitation and recovery of protein by steam injection or other suitable method; (3) separation and recovery of potassium and other inorganic cations by ion exchange; (4) separation and recovery of amino compounds by ion exchange; and (5) recovery of organic acids and phosphates by ion exchange.

Preliminary studies indicate reverse osmosis (RO) is capable of concentrating the large volume of dilute waste water produced by a starch factory before recovery steps are applied. At the same time, the process provides water for reuse in the factory. RO experiments to date with three types of membranes show that one of intermediate porosity is best. This membrane produced the best combination of flux, retention of desirable waste water constituents, and low COD of permeate as demonstrated by the examples discussed.

After concentration by RO, the next step in the treatment process would be precipitation and removal of the protein. This work is being done by our Engineering and Development Laboratory, and so will not be discussed in this report. Next is cation-exchange treatment to recover the valuable free amino acids that are now wasted. By proper selection of ion-exchange column configuration and capacity, a potassium-rich fraction can be obtained without extra cost, and this also makes subsequent recovery of amino acids more effective.

The remainder of this report is limited to the potassium recovery part of the ion-exchange treatment. Optimum conditions were established for exhaustion and elution. Concentration history curves show that a good rate of exchange occurs and that a scavenger column probably is not necessary, even at a fast flow rate of 40 to 60 bed volumes (bv) per hour. The rate depends on the total dissolved solids (TDS) of the feed. Data indicate that a more concentrated feed gives a steeper concentration history curve, and hence is more efficient, than a dilute feed when compared on the basis of time for an equivalent weight of TDS put through the column. This, coupled with the operational advantage of handling smaller volumes, makes it advantageous to use a more concentrated feed. Measurement of conductance of the effluent was found to be a convenient and effective means of monitoring the adsorption of potassium.

Elution of potassium from the column is carried out with H_2SO_4, with 10 percent the optimum concentration. Elution flow rate does not appear to be critical, since the rate of potassium elution is independent of flow rate. The acid eluate is divided into four fractions: (1) void, 0.5 bv; (2) middle, 2 bv;

(3) tailing, 2 bv, and (4) backwash, 1.5 bv. The wash is recycled as wash water. The middle fraction, containing the potassium, is neutralized with ammonia to yield the fertilizer product, which, on a dry basis, has an N-P-K analysis of 12-0-17 to 11-0-22 depending on the hardness of the processing water used. The tailing fraction, being still highly acidic (about 1.7N), is fortified with concentrated H_2SO_4 to 2N (10 percent) and reused as the initial eluant (or regenerant) in the next cycle. This then becomes the middle fraction of the next eluate. The initial eluant is followed by 2 bv of fresh 10 percent H_2SO_4 which becomes the tailing fraction of the next eluate, and thus is reused in the succeeding cycle, etc. The backwash is recycled to the feed tank. In all, 1.2 liters, or 4 bv of 10 percent H_2SO_4 are used to elute (regenerate) the 300-ml. laboratory column; this is equivalent to approximately 25 lb. of 66 deg. Be H_2SO_4/cu. ft. of resin. At this high level of regeneration, the column operates very close to the theoretical capacity.

From the experimental data presented, a possible process can be outlined as follows: Two columns are used to make the process continuous, one to be loaded while the other is being eluted and in the succeeding cycle their roles will be reversed. Since no scavenger column is provided for, the columns would be loaded to the 20 percent leakage level. To load to this level, 25 bv of approximately 1.5 percent TDS feed would be necessary. An exhaustion flow rate of 60 bv/hr. has been shown to be optimum. An elution flow rate of 13 bv/hr. was chosen to make the running time for the elution step equal to that of the exhaustion step. As an example of a specific application, assume a waste effluent from a potato starch plant of 5,000 gal./hr. containing 0.5 percent TDS. Concentration of this effluent to 2.0 percent TDS by reverse osmosis would cut the flow to 1250 gal./hr. of 2.0 percent TDS concentrate. Protein precipitation and removal would lower the TDS to approximately 1.7 percent. Based on the flow rate of 60 bv/hr., this solution would require two columns, approximately 2.8 cu. ft. each, of cation exchange resin. Assuming a potassium content of 12 percent of the TDS after protein removal, this process would yield approximately 21 lb. of potassium/hr. Translating this value to the fertilizer product (ammonia neutralization) yields a weight of 158 pounds of fertilizer/hour or 1.9 tons/day.

Although potassium has been emphasized in this discussion of the data and description of the process, other inorganic cations originally present in the potato, and also those introduced by the water used in the processing, are adsorbed and eluted along with the potassium.

PILOT PLANT STUDY OF THE USDA-MAGNUSON INFRARED PEELING PROCESS

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Background

In 1967-1968 the Western Utilization Research and Development Division of the U. S. Department of Agriculture, Albany, California, announced the development of a new method for the peeling of potatoes. Termed the "dry" caustic peeling method, the process was based on the application of infrared radiation to caustic-treated potatoes followed by abrasion treatment to remove skins. By thus eliminating the use of water for removal of skins, as in conventional caustic or steam peeling, the peeling waste could be removed from the process as a concentrated residue. Experiments were made on single potatoes and in a semicontinuous pilot operation in Albany, and they attracted considerable attention from the potato-processing industry.

Early in 1969, Magnuson Engineers, Inc., of San Jose, California, announced plans for the manufacture of equipment for this process. Magnuson had obtained rights to U. S. Patent 3,370,627, a basic patent issued on February 27, 1968, to Miles Willard, describing this process. Experiments made with the Magnuson equipment at the USDA laboratory confirmed that the Magnuson continuous scrubbing unit could be readily adapted to the process. The basic Magnuson unit, the "Magnupeeler," is widely used for abrasion peeling of potatoes for chipping, or for removal of skins following steam or lye peeling of potatoes.

Later in 1969, Magnuson Engineers, Inc., and the Engineering Committee of the Potato Processors of Idaho (a trade association) agreed to test continuous infrared peeling in a pilot processing line at the Aberdeen, Idaho, plant of Western Farmers Association (previously Idaho Potato Growers, Inc.). Auxiliary equipment was contributed by various members of the Potato Processors of Idaho. Three experimental units were manufactured by Magnuson: the infrared treatment unit, the scrubber, and a final washer. The pilot processing line was operated through May and June until the end of the processing season on June 24, 1969.

This paper will describe the equipment used in these tests, the method of operation, and some of the results obtained.

Design of Pilot Processing Line

Potatoes were removed continuously and randomly from the flow to a conventional caustic peeling line. A surge bin fitted with a variable-speed discharge conveyor regulated the flow through the pilot processing line. A conveyor transported the potatoes to the pilot line in an adjacent part of the building.

A small conventional ferris-wheel type caustic peeler, equipped with temperature controller and circulating pump, was used to apply the sodium hydroxide solution to the potatoes. The concentration was adjusted periodically by adding 50 percent caustic solution. Following application of the solution, a holding belt was used to allow the caustic solution to penetrate to the desired depth. For this a woven wire mesh conveyor fitted with cleats was installed at a slight angle to convey and elevate the potatoes to the infrared treatment unit during the holding period.

The infrared treatment unit consisted of a SHUFFLO feeder, used to align the potatoes in rows and deliver them to a 48-in. roller conveyor, 10 ft. long, which conveyed and turned the potatoes beneath the infrared source. To provide infrared radiation, 8 rows of 6 porous ceramic burners were used, each rated at 20,000 BTU per hour, operating on natural gas. These burners provide a temperature of about 1,650 deg. F. with an output of approximately 50 percent infrared radiation. A rotating wire brush was used beneath the rollers on the return side to brush off the potato skins which adhered.

Because of the particular conditions within this pilot plant it was necessary to elevate the potatoes following the IR unit into the MAGNUSCRUBBER which was fitted with stud rubber rolls to remove the softened skins from the potatoes. Initially a vertical screw conveyor was installed, but this became inoperative. A bucket elevator proved satisfactory as a temporary replacement. In commercial practice the IR unit will be installed so that the treated potatoes can transfer directly into the scrubber.

The MAGNUSCRUBBER contains 23 soft stud rubber rolls, 3 in. in diameter and 6 ft. long, rotating in planetary action at adjustable speeds from 700 to 920 r.p.m. in a continuously rotating cylindrical cage. An adjustable-speed inner screw conveyor controls the residence time in the scrubber. The potato-peel waste removed by this vigorous action is thrown from the rollers by centrifugal force and is collected on the inner surface of a drum supported to rotate about the rolls. A drag conveyor installed in the drum continuously wipes the residue to one point for collection.

The sludge collected underneath the scrubber was either removed for samples or flumed into the waste-disposal system in the plant, as a temporary expedient.

The scrubbed potatoes were then passed through a final brush washing. A MAGNUBRUSHER used for this purpose was fitted with 23 polypropylene cylinder brushes, 3 in. in diameter, arranged in the same planetary manner as the stud rubber rollers in the scrubber. The brushes were adjustable in speed from 480 to 800 r.p.m. An inner screw conveyor also controlled the residence time. Bristles of 0.014 in. in diameter adequately removed any remaining peel residue from the potatoes.

Some scoring of the surfaces of the potatoes was noted with the 0.018-in. bristles originally supplied. The waste from the washer was conveyed away by 2 to 10 g.p.m. of water sprayed into the center of the washer. At a rate of about 4 g.p.m. the washer effluent contained about 2 percent solids. By spraying this liquid into the center of the scrubber to dilute the peel residue, complete recovery of all peel waste was accomplished.

Potatoes peeled by this method have relatively little cooked ring or gelatinized surface, hence they tend to discolor rapidly when exposed to air. Discoloration was eliminated by treating the surfaces of the peeled potatoes with a solution of about 0.5 percent sodium bisulfite before they were conveyed to the trimming area.

When operating with normal peeling conditions the pilot-line potatoes were conveyed directly to the production trim table and added to the commercially produced caustic peeled potatoes for processing into frozen french fries. If the quality of the pilot-line peeled potatoes was not good enough to produce acceptable frozen french fried potatoes, the potatoes were recirculated and peeled again in the plant commercial peeling system.

Operation of Pilot Infrared Peeling Line

The designed capacity of this line was 5,000 lb./hr. input. The feed rate, at times, was momentarily increased to as high as 14,000 lb./hr., but limitations in the pilot-line feed system prevented extended periods of operation at this rate.

The extent of peeling was normally controlled by regulating the time of caustic treatment and the time in the infrared unit. The caustic treatment was varied between 0.4 minute and 1.7 minutes, normally at a temperature of 170 deg. F., with a concentration of 13 to 15 percent. Samples of the caustic-treated potatoes were tested periodically for caustic usage by a direct titration method developed by the USDA laboratory.

The holding belt was normally operated with a residence time between 5 and 10 minutes, with 8 to 9 minutes being optimum.

With all 48 infrared burners operating, a treatment time of 1.0 to 1.4 minutes was satisfactory for activation of the caustic which had penetrated the potatoes. Excessive treatment with the infrared would produce an external cooked ring. The use of less infrared treatment would result in excessive defects and peel fragments on the finished peeled potatoes.

A series of 12 continuous runs was made during the test program in which 23 exact test conditions were recorded with observations of peel quality, peel loss, etc.

Results and Discussion

Time has not yet permitted a complete study of the operating variables to make exact statements on the interaction of peeling loss factors. It is obvious that to remove the peel effectively with minimum solids loss and maximum removal of defects, it is first necessary to penetrate the surface of the potato to a desired depth with the proper amount of caustic solution. It was found that penetration could be controlled by balancing the caustic dip residence time and solution concentration. Temperature of the caustic plays a minor role.

Following the application of the desired amount of caustic, the time on the holding belt permits penetration of substantially all of this material. The infrared treatment must then be adjusted to activate the applied caustic. The rapid absorption of infrared energy in the 2- to 6-micron range effects the desired reaction of the potato tissue in a relatively short time.

An illustration of the test conditions that were used during this period to obtain a "normal" peel is as follows:

Feed rate - 5,500 lb./hr.

Caustic treatment - 12.3 percent concentration, 0.8 minute contact time at 185 deg. F., 9.0 minutes holding belt time.

Infrared burners - 48 burners operating at 20,000 BTU's per hr., effective treatment time 1.2 minutes.

MAGNUSCRUBBER - 1.32 minutes treatment time with rolls operating at 772 r.p.m.

MAGNUBRUSHER - 1.23 minutes residence time with rolls at 778 r.p.m., water rate about 4.6 g.p.m.

Peel-loss measurements were frequently made on both the pilot processing line and the conventional caustic-peeling line. In each test 10 marked potatoes, weighing from 215 to 237 grams per tuber, were weighed before and after peeling, and the percentage weight loss was determined. Trim-loss measurements were also made by extracting about 50 pounds of potatoes from each line, hand-trimming all defects, and determining the percentage weight lost in trimming. Trim loss is an indication of the effectiveness of peel removal.

Following are two tests in which the pilot line and conventional line were producing approximately equal peel removal, as indicated by the identical trim losses on the two lines.

TABLE I.--Comparison of results by conventional caustic peeling and pilot infrared peeling

Item	Test #18		Test #19	
	Pilot line	Conventional line	Pilot line	Conventional line
Trim loss, pct.	5.0	5.0	2.5	2.5
Peel loss, pct.	12.9	20.4	13.1	22.7
Caustic use*	0.18	0.63	0.18	0.63

*Lb. NaOH used per cwt. raw potatoes peeled.

In the majority of tests made during the pilot-plant program, the peel loss in the infrared pilot line was significantly less than that for conventionally peeled potatoes. In tests 18 and 19 shown above, the quality of the peeled potatoes from each process was adjusted as nearly equally as possible, as evidenced by the identical trim-loss results. These potatoes were judged fully peeled and satisfactory for manufacture of frozen french fries.

During these tests a substantial quantity of softened potato tissue adhered to the surface of the potatoes leaving the scrubber. This material was easily removed in the brush washer but contributed a significant waste load to the washer effluent. The sludge discharged from the scrubber is a heavy viscous paste of about 23 percent solids. Combining this sludge with the brush washer effluent reduces it to about 12 to 14 percent solids. In this manner the potato solids in the washer water are eliminated from the waste system and the potato waste from the scrubber is diluted to a point where it can be more easily handled.

Tests performed in the pilot plant using a Moyno pump demonstrated that the scrubber sludge could be pumped even at the original 23 percent solids, but diluting the sludge to about 14 percent solids greatly facilitated its handling.

The effect of the success of this process on the waste disposal problem confronting the potato processing industry cannot be underestimated. The next two figures illustrate flow diagrams of conventional and infrared peeling process plants. In the conventional plant (Fig. 1) both peel waste and plant-processing waste are normally combined, screened, and settled in conventional clarifiers. If the underflow from the clarifier is filtered, it is then combined with the screenings and normally used for animal feeding. The overflow from the clarifier or primary treatment facility containing the dissolved solids is then diverted to secondary treatment, either activated sludge or spray irrigation, or it is disposed in streams.

The general operation of a plant using infrared peeling is shown in Fig. 2. All peeling waste material is discharged as a sludge which can go directly to animal feeding following a period of neutralization by bacterial action. Actually three separate waste materials are produced in the infrared process, the debris brushed from the IR conveyor rollers, the scrubber sludge, and the concentrated washer effluent. These will normally be combined as a total peeling residue and mixed with the screenings and filter cake recovered from the rest of the plant effluent.

In considering the many types of potato-processing plants, the proportion of waste contributed by the peeling step can vary considerably. In the manufacture of dehydrated mashed potatoes, such as potato granules, the peeling can be minimal and may contribute as little as 50 percent of the total plant waste load. For manufacture of frozen french fries, the peel and defect removal must be more complete and may be as high as 75 percent of the total waste load from the plant.

Figure 1. Normal Waste Disposal Practice in Potato Processing Plants

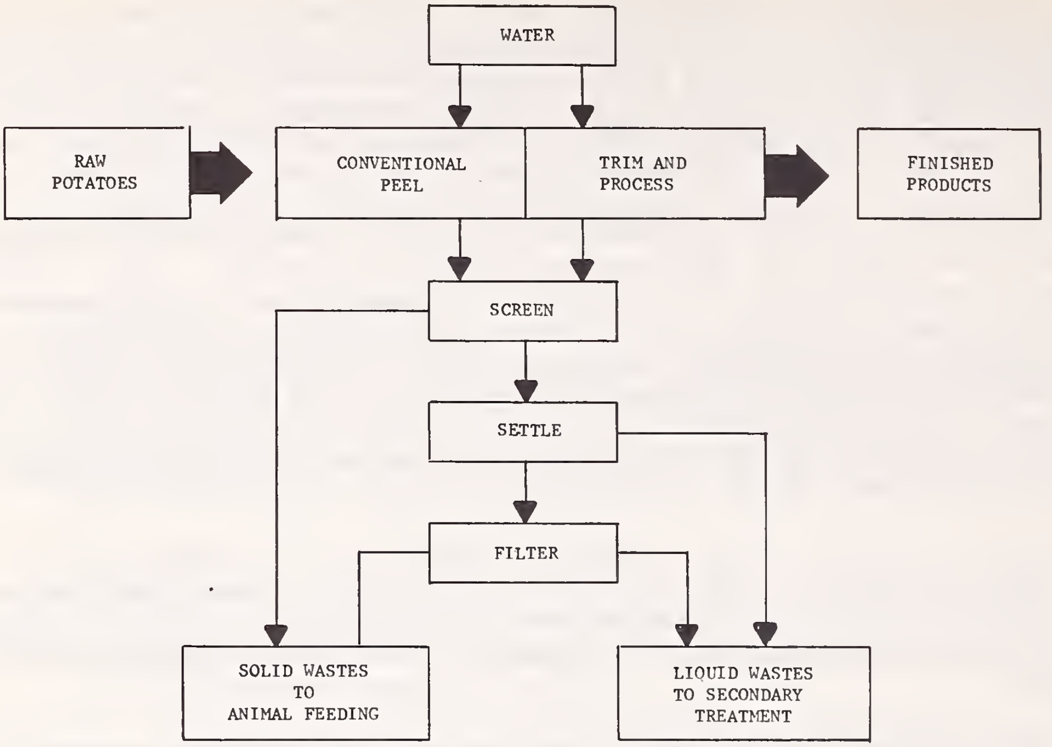
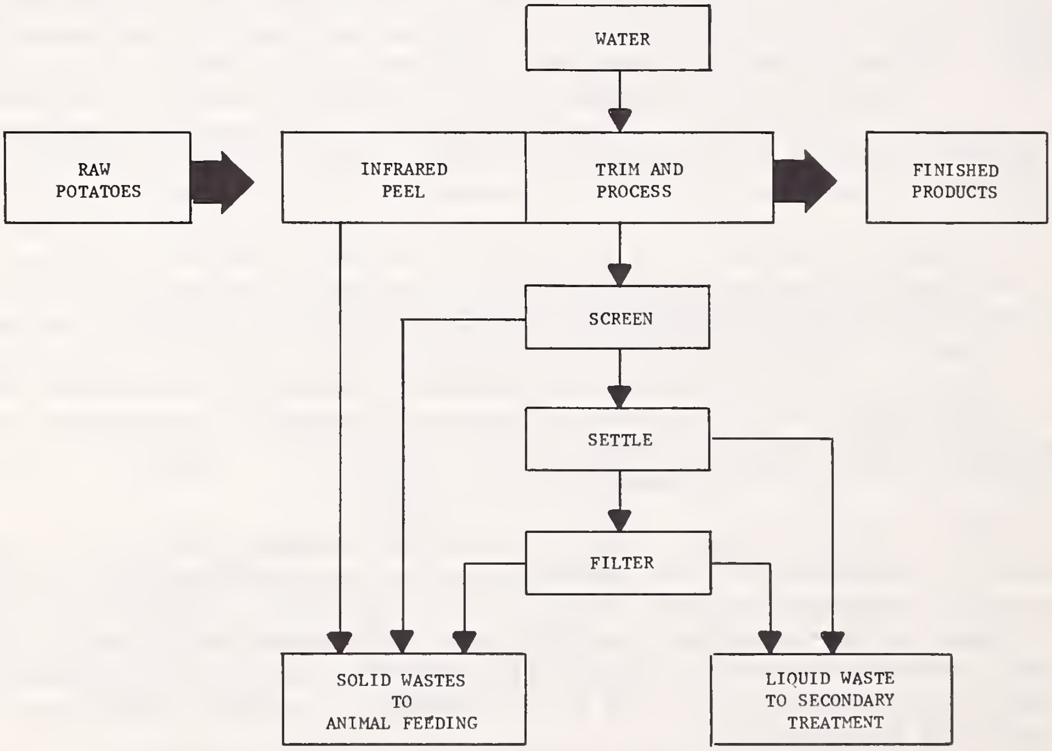


Figure 2. Waste Disposal in Potato Processing Plants Using Infrared Peeling



An estimate of the reduction in waste load to the secondary treatment system using both conventional and infrared peeling for two such hypothetical operations is shown in the following table:

TABLE II.--Effect of peeling method on waste disposal

Item	French Fry Manufacturer		Granule Manufacturer	
	Lye Peel	Infrared peel	Steam peel	Infrared peel
Input, lb./hr.	21,200	20,000	20,000	20,000
Peel loss, percent	18(a)	13(a)	10(b)	10(b)
Peel loss, lb./hr.	3,800	2,600	2,000	2,000
Peeled potatoes, lb./hr.	17,400	17,400	18,000	18,000
Peel waste solids, lb./hr.	760	520	400	400
Non-peel waste solids, lb./hr.	326(c)	326(c)	400(d)	400(d)
Total plant waste solids, lb./hr.	1,086	846	800	800
Primary waste recovery, lb./hr.	543(e)	163(e)	400(e)	200(e)
Total waste solids recovered, lb./hr.	543	683	400	600
Waste solids to secondary, lb./hr.	543	163	400	200

(a) Estimated year-round average, based on pilot-plant observations.
(b) Recovery using IR peeling assumed equal until further data available.
(c) Assuming 70 percent of the total plant loss is peeling loss.
(d) Assuming 50 percent of the total plant loss is peeling loss.
(e) Assuming 50 percent solids recovery in primary clarifier.

From the above table the effect of infrared peeling is seen to be very significant. It appears that in a french-fry plant, the capital investment and cost of operation for secondary treatment can be reduced substantially (163 lb./hr. vs. 543 lb./hr. secondary treatment load). Similarly in a granule plant, the waste solids that must be treated are cut in half (200 lb./hr. vs. 400 lb./hr.).

It is particularly important to note that in the processing of frozen french fries, peeling by caustic is preferred because it affords the best removal of defect particles for a given amount of total peel loss. The secondary treatment from such plants is complicated by the presence of high quantities of sodium ions in the effluent from the primary clarifier. For example, in spray-irrigation practice, the use of continued high-sodium liquid applications to soil have been questioned. With the IR peeling process the liquid waste discharged from the primary treatment contains none of the sodium hydroxide used in peeling, thereby making stream or land disposal potentially more feasible.

Conclusions

1. Operation of a continuous pilot plant has confirmed the results reached by the earlier work of the USDA Western Utilization Research and Development Division, namely that the USDA-Magnuson infrared peeling process can be operated continuously on a commercial basis.

2. Substantially all of the potato tissue removed in peeling in a potato processing plant can be concentrated into a single residue, bypassing the waste-disposal system of the plant.

3. Reduction in caustic usage of about 65 percent predicted by the USDA research was confirmed.

4. A substantial reduction in peel loss was indicated by the pilot-plant tests when compared to the conventional caustic peel line in operation on the same potatoes at the same time. The confirmation of the reduced peel loss for the IR process was established by the equivalent trim-loss measurements made on the potatoes peeled by both methods.

TEXTURE OF COOKED POTATOES AND ITS MEASUREMENT

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The cooked potato texture that I'm going to talk about deals exclusively with baked potato. We chose to work with the baked product because it seemed to us that with this, texture is the primary critical characteristic, and we had preconceived ideas that mealiness, flouriness, friability or what-you-may-call-it is paramount in baked potato acceptability. In addition, it seemed that preparation in this form may be better controlled and less subject to such possibly confounding influences as leaching or sloughing in boiled potatoes or variations in fat absorption, sugar content, etc., in french fries or chips. Thus, with this relatively homogeneous material, taste-panel decisions should be more reproducible than with any other form of preparation.

Materials: All of the tubers were grown at Aroostook Farm in Presque Isle, Maine. All cultural conditions--planting dates, fertilizers, pesticides, herbicides, and sprout inhibitors, concentrations, methods and times of application--were exactly the same in any one season. Harvesting and grading were done at the same time, and the tubers were stored under the same conditions at 45 degrees F.

Shortly before the series of panel evaluations, the potatoes were brought to Orono and separated for specific gravity by brine flotation in increments of 0.002 ± 0.001. The tubers needed for various tests were taken from the assembly line, marked with Floquil pens for gravity, variety, and other needed identification, and stored at 45 degrees F. until tested. All of the tests were done as soon as possible after separation. Six weeks was the longest time before all testing was completed.

We planned to use 10 tubers for each taste replication, although occasionally it was necessary to settle for 6 from the extreme ends of the gravity distributions. When reference standards were used, double this number of the standard was needed--to serve for both external and internal standards. Tubers for each test were removed from the cooler on the day before the test and were stored at room temperature overnight.

Sample preparation: The tubers were cooked at 425 degrees F. until tender to a fork. They were then riced, mixed lightly with a fork, and served to the taste-panel judges at room temperature. We saved ourselves much experimental time by accepting the results of two studies which we did on the relationship of panel mealiness ratings to cooking time. Each was a 6-sample study including three Kennebecs and three Russet Burbanks of the same specific gravity (1.090). The potatoes were assumed to be "done" when the internal temperature, as measured with a thermocouple, reached 208 degrees F. Three tests were conducted, each with three experimental variables related to the doneness of the potatoes, and the samples were evaluated by taste-panel judges who rated them on a 5-point mealiness scale: Dry, mealy (+2); Moderately mealy (+1); Slightly mealy, somewhat moist (0); Moderately moist (-1); and Wet, soggy (-2). The results are summarized in Table I.

Table I.--Effect of cooking time on mealiness of baked potatoes as determined by taste-panel scores subjected to variance analyses (Kennebec and Russet Burbank potatoes, spec. grav. 1.090)

Test				Internal temp.	Cooking time beyond internal temp.	Panel ratings	
No.	Judges	Trials	Variety	(deg. F.)	(min.)	Mean score[1]	Signif.[2]
1	33	4	Ken.	208	20	0.54	S.

			Ken.	198	0	0.43	
			Ken.	208	0	0.42	
			R.B.	208	20	0.41	
			R.B.	208	0	0.33	

			R.B.	198	0	0.16	
2	26	3	R.B.	208	0	0.68	N.S.
			R.B.	208	20	0.56	
			Ken.	208	10	0.47	
			R.B.	208	10	0.42	
			Ken.	208	20	0.42	
			Ken.	208	0	0.38	
3	29	1	Ken.	208	10	0.55	N.S.
			R.B.	208	10	0.48	
			Ken.	208	30	0.45	
			Ken.	208	20	0.41	
			R.B.	208	20	0.41	
			R.B.	208	30	0.41	

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[1] +2 Dry, mealy; +1 Moderately mealy; 0 Slightly mealy, somewhat moist; -1 Moderately moist; -2 Wet, soggy.

[2] S. Data separated by broken line approaching significant difference at P = 0.05. N.S. Not significant.

In the first test, underdone (198 degrees F.), done (208 degrees F.), and overdone (208 degrees F. + 20 min.) potatoes of each variety were evaluated by a 33-judge panel. The judges gave the six samples mean scores ranging from 0.16 to 0.54--differences of no practical significance, although when the data were subjected to analyses of variance (as all the data were), they approached a significant difference at P = 0.05. In this test there seemed to be a trend favoring Kennebec over Russet Burbank. In the next test, conducted three months later in the same manner with 26 judges, the variables were 208 degrees F., 208 degrees F. + 10 min., and 208 degrees F. + 20 min. Here there was no significance to the relationship of mealiness to cooking time or to variety. In a third trial using 29 judges, the samples were cooked 10, 20, and 30 min. beyond the doneness temperature of 208 degrees F., and again, no significance was attached to the cooking time.

Thus, the exact moment of doneness was not critical in the sensory evaluation of mealiness for the conditions used in these studies, which embrace the range of the conditions in use now at our laboratory. When the texture of these samples was determined in the extrusion (shear) press, the values showed less variability among replicates when the potatoes were baked 20 min. beyond the doneness temperature of 208 degrees F., so this condition was observed in preparing samples for tests when shear measurements were planned.

After serving, samples were taken from the same mixed potatoes for total solids determination (20 gm. dried in a vacuum oven at 70 degrees C., 28 p.s.i. for 17 hr.) and for extrusion-press evaluation (150 gm.).

The primary reason for serving the baked potatoes in the riced form was to facilitate uniformity of the samples without masking the integrity of the granules. The riced contents of 10 potatoes may be mixed lightly with a fork without reducing the mixture to a paste. Beyond these preconceived reasons, we have evidence that the precision achieved by our panels with riced potatoes is at least as great as with diced potatoes, if not greater.

Four tests demonstrated this point. Two were by the Scheffé paired comparison method (7) using 8 pairs of samples: Russet Burbanks and Kennebecs, each of two specific gravities, 1.094 and 1.086. These were judged as riced and as diced by the same judges on halves (bud end to stem end) of the same tubers. The other two were multiple comparisons of three varieties (Kennebec, Sebago, and Plymouth), each of two specific gravities, 1.088 and 1.082, which were ranked for mealiness as riced and as diced. Data are shown in Table II. In all cases, the treatment F values were higher in tests of the riced samples, and in three cases contrasts were detected at a higher significance level. In one test (Kennebec, paired comparison) there was a significant difference in the magnitude of the treatment F values (favoring riced) when they were compared by the Bradley-Schumann method (1). On this evidence, we continue to use the riced form to evaluate mealiness. We use baked, riced potato also for detection of flavor differences associated with pesticides on the presumption that there would be less opportunity for dissolution, leaching, or volatilization of chemical residues.

Table II.--Comparison by variance analyses of taste-panel scores for mealiness on potatoes prepared by ricing and by dicing

A. Paired comparisons: 2 varieties, 2 specific gravities

Variety	Spec. Grav.	Choices[1] (16 judges, 8 reps.)				Intensity[2] (16 judges, 8 reps.)		
		Mean scores[3]		Treatment		Mean scores		Treatment
		Riced	Diced	F[4]	Comparison of F's[5]	Riced	Diced	F[4]
Russet	1.094	+0.66				+1.14		
Burbank		=====		36.15**		=====		52.90**
	1.086	-0.66				-1.14		
					N.S.			
	1.094		+0.44				+0.92	
			=====	15.64**			=====	21.53**
	1.086		-0.44				-0.92	
Kennebec	1.094	+0.47				+0.88		
		=====		23.60**		=====		19.93**
	1.086	-0.47				-0.88		
					15.21**			
	1.094		+0.19				+0.53	
				1.55 N.S.			-----	6.03*
	1.086		-0.19				-0.53	

B. Rankings: 3 varieties, 2 specific gravities

Variety	Mealiness Rankings[6]					
	Spec. grav. 1.088, stored at 55°F. (19 judges, 4 reps.)			Spec. grav. 1.082, stored at 45°F. (21 judges, 4 reps.)		
	Mean scores[3]		Treatment	Mean scores[3]		Treatment
	Riced	Diced	F[4]	Riced	Diced	F[4]
Kennebec	+49			+53		
	====			====		
Sebago	+ 1		59.53**	+22		107.7**
	====			====		
Plymouth	-50			-75		
Kennebec		+39			+55	
		----			====	
Sebago		+16	44.06**		- 1	50.96**
		====			====	
Plymouth		-55			-54	

[1] Paired comparison choices: +1 more mealy; -1 less mealy.

[2] Six-point scale to indicate intensity of preference, from +3 to -3.

[3] Broken lines separating mean scores indicate least significant differences of the preferences, double line at P = 0.01, single line at P = 0.05, no line if lower order of significance.

[4] Asterisks indicate significance of F values, ** at P = 0.01, * at P = 0.05, N.S. = not significant.

[5] $\frac{\text{F for riced}}{\text{F for diced}} \times 100$ W value of Bradley and Schumann (1); Needed for significance, W_o: 5.64.

[6] Ranked in order of mealiness: +1, 0, -1.

For some time we have been attempting to characterize baked potato texture by words meaningful to the panel members and, we hope, to consumers. We started with a 5-point scale using the descriptive words indicated above and in Table I. There is evidence that the presence of an external standard (labeled reference) helps to anchor the judges to a common ground. We didn't know what a reference sample should be in terms of words, specific gravity, or total solids, so our first chore was to have the panels determine a standard of reference that would represent the mid-point on our mealiness scale (Slightly mealy, somewhat moist). Our first study on this problem involved stored Kennebecs (7 samples) with specific gravity increments of 0.004 (which we had previously determined to be detectable by panels as a mealiness difference). For this test, the mid-point (nearest to 0) came out to be 1.078 specific gravity, with a coincident total solids of about 20 percent. A second test on the same variety from the next year's crop revealed the mid-point to be 1.067 specific gravity and about 21 percent total solids--quite a discrepancy. After 11 such tests with Kennebecs and Russet Burbanks, the data were submitted to regression analysis, which showed the statistical mid-point to be 1.078 (with a standard error of 0.004) and 21.32 percent total solids (with a standard error of 0.87). In the 11 tests, the judged mid-point varied from 1.067 to 1.086 specific gravity and from 19.77 to 24.16 percent total solids (5). The unreliability of specific gravity to predict total solids poses a problem in getting a reference sample constant for solids. It is simpler to use specific gravity and to correct later for variations in total solids by covariance analysis.

In the pursuit of these studies, it was observed that few of the judges were classifying the samples at the extreme ends of the scale, i.e., Dry, mealy, or Wet, soggy, and none of the mean panel scores were so classified. There were, however, many significantly different scores within each of the three categories that were used. This led us to suspect that our words were not truly descriptive of the textures as the panel members saw them--over and above a general resistance to the use of scale ends.

This past season we tried a comparison of the 5-point scale with a 7-point scale. The latter consisted of the following designations, with the two added ones underlined: Extremely dry, mealy; Dry, mealy; Moderately dry, mealy; Neither dry nor moist; Moderately moist; Moist, pasty; and Wet, soggy. Our 30-member taste panels were divided randomly so that half used the new 7-point scale and half used the original 5-point scale. We did four comparative tests of the two scales, two tests with Katahdins and two with Kennebecs. The Katahdin tests each used 6 samples and the Kennebec tests consisted of one using 6 samples and the other using 5. The specific gravities of the samples progressed (in increments of 0.006) from 1.060 to 1.108, and their total solids ranged from 17.1 to 28.4 percent. The judges in these tests were presented with a labeled reference sample of 1.078 specific gravity for the mid-scale point (Neither dry nor moist).

These experiments failed to show any clear-cut consensus favoring the 7-point scale over the 5-point scale. All the designations of the 5-point scale, including Dry, mealy and Wet, soggy at the ends, were used--in fact, the only categories not represented in the mean scores were the two that were added. Whether the judges used the 5-point scale or the 7-point scale, their mean scores were in agreement for all but 4 of the 23 samples. The 4 discrepancies involved 2 Katahdin and 2 Kennebec samples: The Katahdins were both judged Dry, mealy on the 7-point scale and Moderately dry, mealy on the 5-point scale; and of the 2 Kennebecs, one was judged Neither dry nor moist on the 7-point scale and Moderately moist on the 5-point scale, and the other was given the same two designations, but reversed, by the 7- and 5-point scales.

Another area which we felt should be investigated was the preference of the panels for the mealiness of baked potatoes in terms of total solids.

Although it is usually assumed that there is a direct linear correlation between total solids and superior quality in the texture of baked potato, it was conceivable that there could be a "too-dry" point at or above which acceptability might be lowered.

To investigate this point, seven studies were done during the past season: two each of Kennebecs and Russet Burbanks in December and in March and three of Katahdins in December, March, and May. Most of the tests were of six or seven samples differing by 0.006 specific gravity. One Russet Burbank study was of 5 samples, and the samples in one of the Kennebec studies differed in specific gravity by 0.006, 0.008, and 0.010. The panels were divided randomly, half ranking the samples according to mealiness and the other half according to preference. Within a test, samples for the two panels were from the same pots of riced potatoes.

The data in Tables III and IV demonstrate that indeed the highest preference is not universally for the highest-solids potatoes. The judges ranked samples of baked Russet Burbank, Kennebecs, and Katahdins of varying total solids for (a) mealiness and (b) preference. Their preference disagreements were so great that rankings by this criterion were consistently far lower in significance than rankings for mealiness, and in one case the preference rankings were not significantly different at all. The F's were not compared by Bradley-Schumann because significant W's would tell us only of judge disagreement. In fact, we weren't quite sure how to handle these data because the total solid ranges within each study differed, and it would be difficult to prefer 30 percent total solids if it isn't there. Thus data from the different tests were not strictly comparable.

Finally, we calculated the percentages of first choices in terms of total solids based on the opinions of the judges who detected significant overall differences and who sampled the specified total solids. The distribution of these options is shown in Table IV, where it is seen that the highest solids available was not always the first choice. Total solids of 27-30 percent was too dry for many judges, and a few preferred a relatively moist baked potato. Our approach doesn't tell us about the significance of these preference differences.

Nine differences of 0.006 specific gravity (average of 1.4 percent total solids) among 38 contrasts were not detected as mealiness differences--a bit disconcerting in view of our recent paper showing that the specific gravity differences of 0.004 were detectable by panels (6). Two possible answers occurred to us: the conclusion in the threshold studies was based on presentations of 3 samples at a time whereas these embraced 6 or 7 simultaneously. We do have previous evidence that 6 or 7 samples of potatoes can be judged as easil as 2 or 3. Another possible explanation is the smaller panels in these tests

Table III.--Comparison of taste-panel rankings for mealiness and preference of baked potatoes with range of total solids

A. RUSSET BURBANKS

Test	Mealiness			Preference		
	No. of judges	Rank[1]	Assoc. total solids (percent)[2]	No. of judges	Rank[1]	Assoc. total solids (percent)[2]
1 (December)	16	1a	27.8	16	1	24.2
		2a	29.3		2	27.8
		3ab	26.4		3	26.4
		4b	24.2		4	29.3

		5c	23.5		5	23.5
		F = 9.8			F = N.S.	
2 (March)	16	1	29.5	16	1a	29.5
		...				
		2	27.2		2a	27.2
		3	26.0		3a	23.3

		4	24.6		4a	26.0
		===				
		5	23.3		5a	24.6
		===				
		6	21.4		6ab	21.4
		...				
		7	20.9		7b	20.9
		F = 49.3			F = 3.2	

[1] Determined from variance analyses of transformed scores of ranks by method of Fisher and Yates (4). Significance of differences between ranks according to Duncan (3) is shown by letters and by lines separating successive ranks. No significant difference between ranks that are followed by the same letter. Double dashed line shows significance at P = 0.01, single dashed line at P = 0.05, dotted line at P = 0.10; no line indicates no significant difference. F values for sensory tests are significant at P = 0.01.

[2] By analysis.

Table III (Cont.).--Comparison of taste-panel rankings for mealiness and preference of baked potatoes with range of total solids*

B. KENNEBECS

	Mealiness			Preference		
Test	No. of judges	Rank^1	Assoc. total solids^2 (percent)	No. of judges	Rank^1	Assoc. total solids^2 (percent)
1 (December)	15	1	28.0	16	1	25.7
		2	28.6		2	23.6
		===				
		3	25.7		3	28.6

		4	23.6		4	28.0
		===				
		5	22.4		5	22.4
		===			===	
		6	20.5		6	20.5
		F = 39.0			F = 3.9	
2 (March)	15	1	30.0	16	1	26.1
		2	28.6		2	24.0

		3	27.1		3	27.1
		4	26.1		4	22.0
		===				
		5	24.0		5	30.0
		===				
		6	22.0		6	28.6
		===			---	
		7	20.8		7	20.8
		F = 40.2			F = 4.8	

* For numbered footnotes, see first page of table.

Table III (Cont.).--Comparison of taste-panel rankings for mealiness and preference of baked potatoes with range of total solids*

C. KATAHDINS

Test	Mealiness			Preference		
	No. of judges	Rank[1]	Assoc. total solids (percent)[2]	No. of judges	Rank[1]	Assoc. total solids (percent)[2]
1 (November)	15	1	26.3	15	1	26.3
		2	25.6		2	25.6
		===				
		3	23.8		3	21.2
		===				
		4	23.4		4	23.8
		===				
		5	21.2		5	23.4
		===				
		6	20.1		6	20.1
		===			===	
		7	18.9		7	18.9
		F = 254.9			F = 7.5	
2 (March)	16	1	26.4	16	1	23.6

		2	25.2		2	26.4
		===				
		3	23.6		3	25.2
		===				
		4	22.7		4	22.7
		===			---	
		5	20.9		5	20.9
		===			...	
		6	19.4		6	19.4
		F = 148.1			F = 6.6	
3 (May)	13	1	27.7	11	1a	24.1
		...				
		2	26.3		2ab	24.7
		3	24.7		3ab	26.3
		===				
		4	24.1		4abc	22.4
		5	22.4		5bc	27.7
		====				
		6	21.0		6c	21.0
		===			===	
		7	18.8		7d	18.8
		F = 48.6			F = 11.1	

* For numbered footnotes, see first page of table.

Table IV.--Judge preferences for total solids in three varieties of baked potatoes[1]

Russet Burbanks (2 tests)		Kennebecs (2 tests)		Katahdins (3 tests)	
Percent 1st Place Choices[2]	Total Solids Range	Percent 1st Place Choices[2]	Total Solids Range	Percent 1st Place Choices[2]	Total Solids Range[3]
29.6	23.0-23.9	33.3	25.0-25.9	37.5	26.0-26.9
27.3	29.0-29.9	25.0	26.0-26.9	21.2	24.0-24.9
15.9	26.0-26.9	25.0	23.0-23.9	18.0	25.0-25.9
12.5	28.0-28.9	19.2	22.0-22.9	12.0	23.0-23.9
10.7	27.0-27.9	15.8	28.0-28.9	9.1	27.0-27.9
6.8	24.0-24.9	14.3	27.0-27.9	9.1	20.0-20.9
0	21.0-21.9	10.7	29.0-29.9	8.3	21.0-21.9
		7.1	24.0-24.9	8.0	22.0-22.9
		0	21.0-21.9	2.8	19.0-19.9

---

[1] Based on opinions of judges who detected significant overall differences and who sampled the specified total solids.

[2] $\frac{\text{No. in 1st place}}{\text{No. of Significant Judges}} \times 100.$

[3] There were no Katahdin samples above 27.9 percent total solids.

(11 to 16). Errors of the second kind may be at work, and more judges and/or replications are needed. These hypotheses can only be validated by tests.

Finally today we have a few data in the area of the "relative nature of human preference for foods," which was documented by Dove (2) for sweet corn quality. His data showed that preference for sweet corn varieties depended upon the quality of other samples presented simultaneously, e.g., an unknown variety was called "sweet and tender" when presented with inferior samples and "flat and tasteless" when compared with superior quality varieties.

Because all of us in our passion for reproducibility and uniformity use comparative methods for characterizing flavor and texture, with multiple sampling or at the least paired comparisons rated or ranked for preference or attributes, we are perhaps justifiably criticized for our pronouncements on food quality. Our results are derived from samples tasted "out-of-context" in series or pairs, and our conclusions may not truly reflect a consumer's response to a single sample.

It was pertinent, then, to investigate the panel's responses to a single sample (monadic) as opposed to or compared with its responses to two or more samples at a time in order to predict consumer reaction more effectively.

Thus, our final observations to be reported today compare multiple (3 at a time) with monadic (single) sample presentation to determine if texture decisions are the same when better or poorer samples are not available for relative decisions.

In 1966, 3 samples of the Sebago potato of specific gravities differing by 0.008 (1.090, 1.082, and 1.074) were presented to 20-member panels in complete blocks (4 replications), and then the same samples were presented one at a time with at least 30 minutes between samples. The judges rated the samples on the 5-point scale with no external standard.

The data for Sebago in Table V show that the panel was significantly less discriminating when the single sample alone was evaluated, although the contrasts were all significantly detected. The F value for treatment was significantly larger for the multiple presentations. The judges gave all the Sebago samples the same characterization for mealiness whether they used the multiple or the monadic method.

In 1967-68, six additional tests were conducted in the same manner with Russet Burbank, Kennebec, and Katahdin, differing in specific gravity by 0.006 in one series of three samples, and by 0.004 in another series, each rated three at a time and singly with four replications by panels of 19 to 22 members. In these two series of tests, there was no consensus favoring the multiple method: with the samples differing in specific gravity by 0.006, the F's for the multiple sample tests were higher with Russet Burbank and Kennebec, favoring the multiple method, and the reverse was true with Katahdin. But the treatment F's were not significantly different in any of the comparisons (1).

In the 0.004 specific gravity series, the treatment F's were quite similar in magnitude. One contrast by the multiple method and another one by the monadic method were not significantly different.

Table V.--Comparison of multiple- and monadic-sampling to characterize potato mealiness

Variety	Date	Specific gravity	Total solids (percent)	Mean score[1]	
				Multiple	Monadic
Sebago	Dec. 1966	1.090	23.2	+0.81	+0.71
				=====	=====
		1.082	21.2	-0.06	+0.16
				=====	=====
		1.074	19.9	-0.78	-0.46
				F = 103.84	F = 35.18
Russet Burbank	Apr. 1968	1.086	23.7	+1.06	+0.99
				=====	=====
		1.080	22.2	+0.65	+0.59
				=====	=====
		1.074	20.8	-0.21	+0.02
				F = 73.07	F = 35.38
Kennebec	Nov. 1967	1.086	23.5	+1.24	+1.02
				=====	=====
		1.080	22.5	+0.69	+0.72
				=====	=====
		1.074	21.1	-0.06	+0.25
				F = 60.58	F = 30.81
Katahdin	Feb. 1968	1.086	22.6	+0.96	+0.87
				=====	=====
		1.080	22.2	+0.51	+0.37
				=====	=====
		1.074	20.1	+0.08	-0.13
				F = 39.06	F = 55.46
Russet Burbank	May 1968	1.084	23.8	+1.00	+0.94
				=====	=====
		1.080	22.4	+0.50	+0.82

		1.076	21.3	+0.43	+0.40
				F = 16.52	F = 14.41
Kennebec	Dec. 1967	1.084	23.3	+0.79	+0.72

		1.080	22.2	+0.50	+0.55
				=====	=====
		1.076	21.6	+0.01	0
				F = 22.8	F = 16.46
Katahdin	Mar. 1968	1.080	21.9	+0.57	+0.50
				=====	=====
		1.076	21.0	+0.23	+0.19
				=====	-----
		1.072	19.3	-0.30	-0.05
				F = 23.03	F = 12.65

[1] Panel of 19 to 22 judges scored samples on 5-point scale (see Table I) without labeled reference standard. Broken lines separating mean scores indicate least significant differences, double line at P = 0.01, single line at P = 0.05, no line if lower order of significance. F values all significant at P = 0.01. F pairs not significantly different at P = 0.05, except for Sebago, where W = 2.95.

All the contrasts at the 0.006 specific gravity difference were rated significantly different by both methods. The judges gave all 18 samples in the two test series the same characterizations for mealiness whether they used the multiple or the monadic method, with three exceptions (one sample from each of the three variety groups was rated more mealy by the multiple technique).

So all of the evidence that we have accumulated (except that from the first test with Sebago) indicates that the monadic test is as precise as the multiple for rating the mealiness of three varieties of baked potatoes in samples differing in specific gravity by 0.006 or by 0.004, and that generally the characterization of mealiness is similar.

Summary

Three tests showed no differences in panel scores for baked potatoes of the same variety and specific gravity, whether underdone (198 deg. F), done (208 deg. F), or done plus 10, 20, or 30 minutes. In 4 tests, panels showed somewhat more acuity in detecting texture differences in riced than in diced baked potato. To characterize potato texture on a scale from "Dry, mealy" to "Wet, soggy," the evidence from 4 tests showed that a 7-point scale had little, if any, advantage over a 5-point scale, when an external standard was used. In an attempt to find the preferred mealiness in terms of total solids of baked potatoes, ranking of 5, 6, or 7 samples of 3 varieties in 7 tests showed large judge disagreement and wide distribution of percent preferences. Six tests of potatoes differing in specific gravity showed that panels discriminated equally well when judging one sample at a time or 3 at a time. One test showed significantly better discrimination by the multiple method.

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RELATIONSHIP OF STRUCTURE AND TEXTURE IN POTATOES

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Structure and texture of fruits and vegetables are nearly synonymous because texture concerns the manner by which the individual parts of a substance are held together. This influences qualities of appearance, such as coarseness or stringiness in some ripe fruits, and of feel, such as mealiness in some ripe apples or in baked potato. Only some of these many textural qualities are directly measurable by physical means. Many, however, show relationship to compositional features. Thus texture also concerns composition.

Composition of the potato varies according to the structural and functional characteristics of the several tissues. Composition also involves differences between tuber zones, varieties, growing and harvesting conditions, and storage histories. Add to all this the inescapable fact that these structural and compositional variables are differently influenced by different processing treatments, and the potential magnitude of texture problems in processed products becomes impressive. In the past 25 years the surge of the potato processing industry, with its new processes and new products appearing yearly, has compounded the need to understand the sources of texture problems--both those inherent in the tuber and those arising as a result of process-induced changes.

The degree of variation within the tuber relates directly to how the tuber grows. Artschwager (1) found that nearly all tuber growth originates from procambial activity in the perimedullary zone just inside the xylem "ring." A brief review of this origin is illustrated in Figures 1 to 3. Tuberization occurs when the terminal bud of an underground stem or rhizome begins to expand both longitudinally and laterally. The terminal bud is maintained at the apical or bud end of the young tuber. New axillary or lateral buds of future tuber "eyes" begin to form early in tuberization.

By the time the young tuber is about 2 mm. in diameter, organization of all tuber zones and tissues has become established (Figure 3). A periderm (corky skin) has begun to form under the epidermis which is later sloughed. The primary vascular tissues, xylem and phloem, are being differentiated from the procambium. The phloem includes both outer and inner strands, a characteristic of the Solanaceae, the potato family. Continued procambial differentiation around inner phloem strands forms new starch-storage parenchyma. Some growth of this sort occurs around outer phloem strands and some random cell divisions in young parenchyma throughout the tuber accommodate for the pronounced inner growth. By the time the young tuber is about an inch in diameter, cell divisions diminish in frequency and cell enlargement becomes the more dominant form of growth. At about the same time, differences in amounts and size of starch granules become evident in the different tissues. It is likely that other compositional differences also are initiated. These differences in starch relate to texture problems peculiar to different processing treatments.

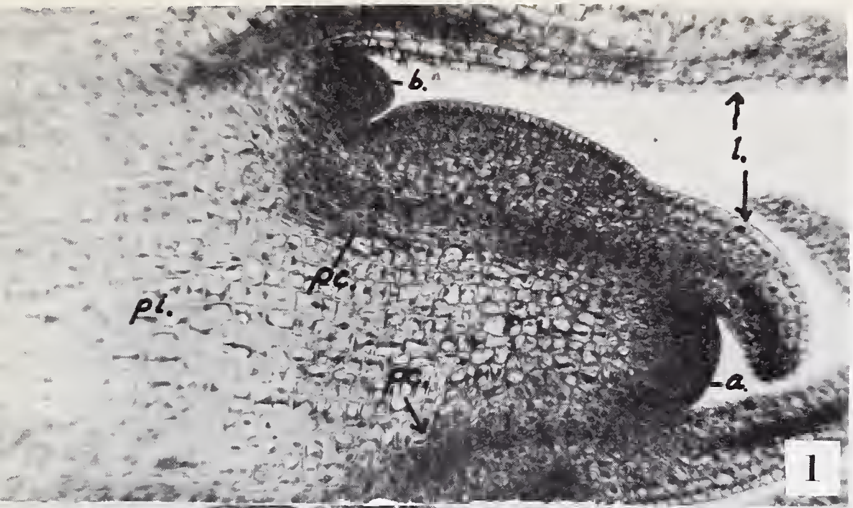


Figure 1. Median longitudinal section of terminal bud of stolon or rhizome just beginning to expand.

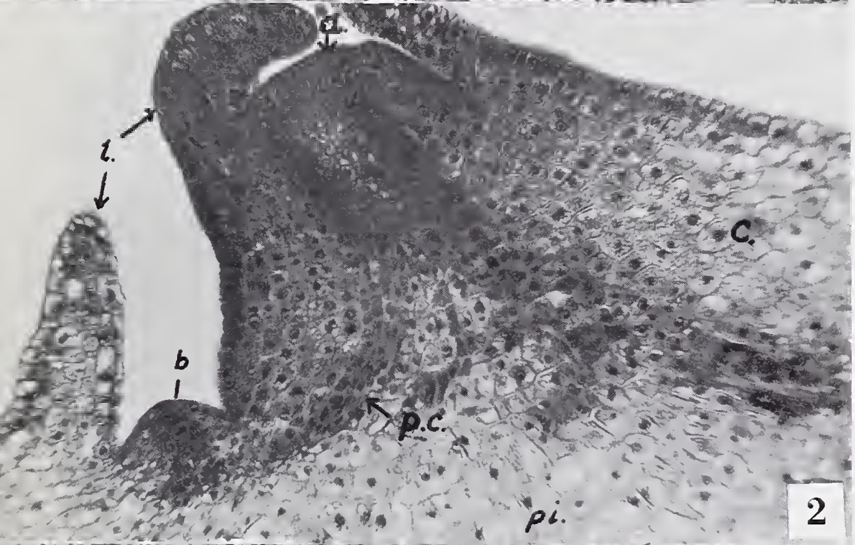


Figure 2. Near median longitudinal section of terminal bud at opical "eye" of tuber about 2 mm. in diameter.

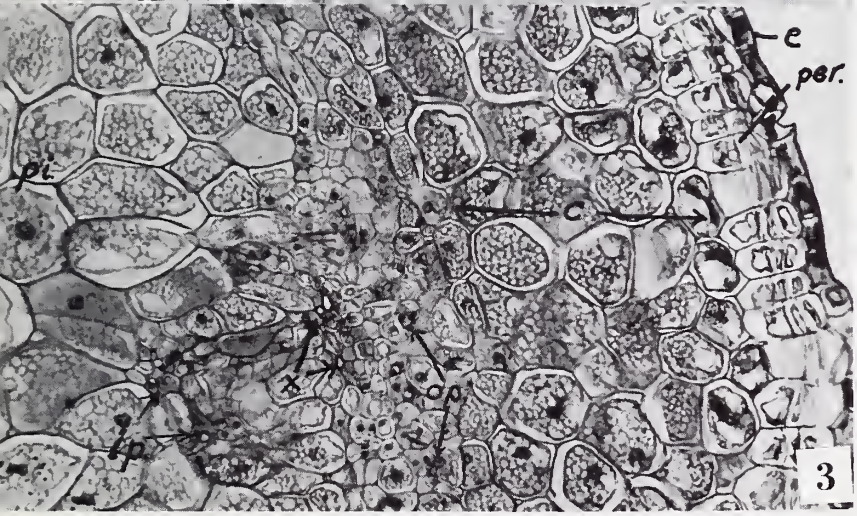
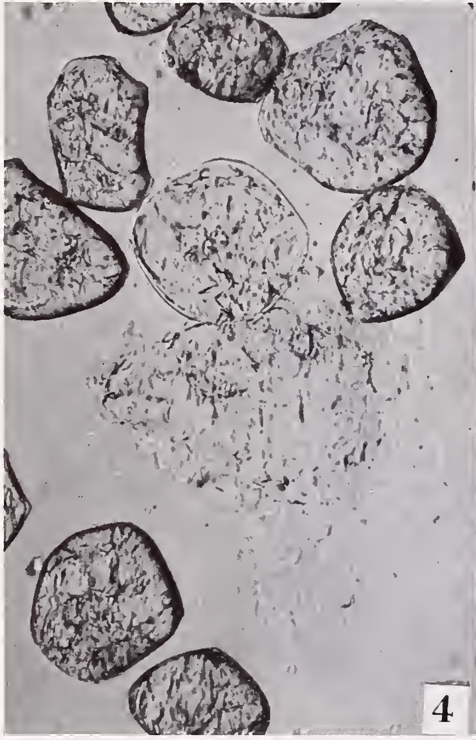


Figure 3. Transverse section near middle of young tuber 2 mm. in diameter. Perimedullary parenchyma just beginning to differentiate around inner phloem.

Legend

a.	Apex	c.	Cortex	per.	Periderm	ip.	Inner phloem
b.	Lateral bud	l.	Young scale leaves	pi.	Young pith	op.	Outer phloem
		pc.	Pro cambium	e.	Epidermis	x.	Xylem

If we begin with what we know of some of the more obvious changes caused by processing, and how they relate to texture, then it can be seen how this basic information on tuber structure applies. For example, when potatoes are cooked, their starch contents are gelatinized. Some potatoes undergo ready cell separation and become mealy when baked. When they are boiled and mashed, it is readily seen that rupture of some cells releases gelled starch which, in excessive amounts, causes stickiness (Figure 4). Stickiness from cell rupturing during manufacture of dehydrated mashed potatoes and during their reconstitution has been controlled to a significant degree by use of emulsifiers, such as glycerides, which complex with starch--principally with the soluble amylose fraction (8). It is also known that added sugars influence the properties of potato starch gels (13). It seems reasonable that some of the sugars accumulated in stored potatoes may significantly alter their culinary texture.



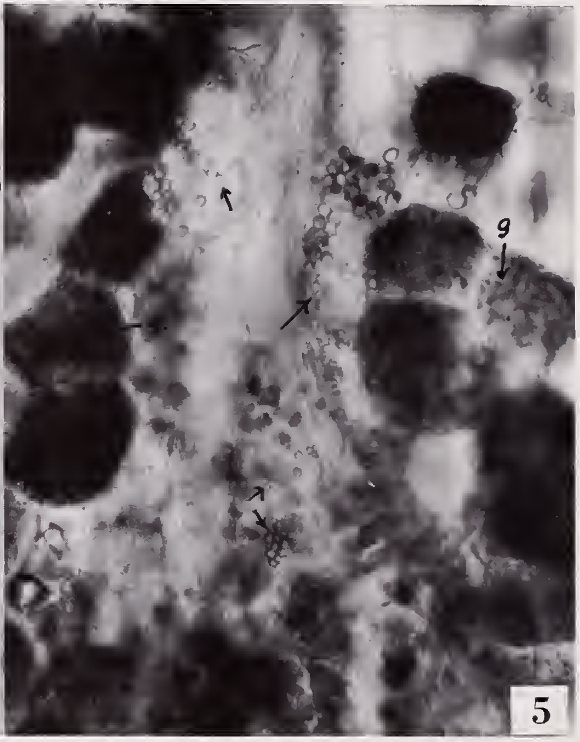
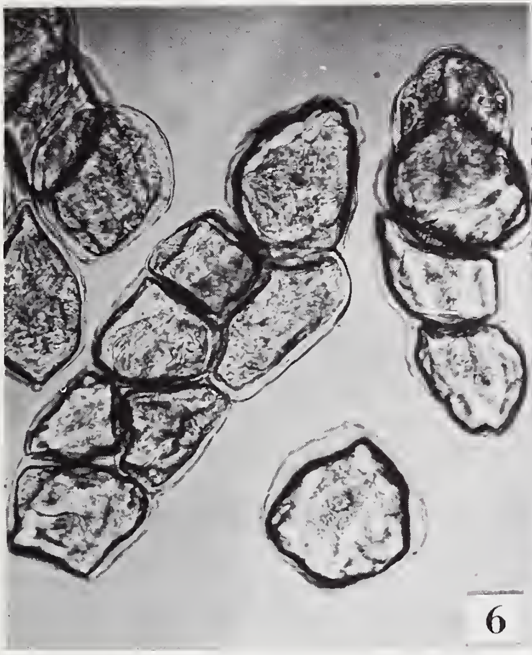


Figure 4. Cells from cooked potato showing one ruptured cell with extruded starch gel.

Figure 5. Section cut from xylem "ring" of a potato slice heated 1/2 hr. at 65 degrees C. showed small ungelled starch granules (arrows) and completely gelled starch in adjacent starch-storage parenchyma.

The amylose/amylopectin ratio varies according to tuber age, variety, and size of starch granules (4, 10). These differences influence temperature of gelatinization (a full range being about 58 to 72 degrees C.) and also result in different gel properties. For example, the smallest granules in the xylem and phloem areas resist gelatinization at low heating temperatures (Figure 5). Low-temperature heating, as in precook heating, also influences gel properties; the granules do not swell excessively and the starch gel retrogrades. The tissue then does not readily slough upon finish cooking (7). This treatment affords some control over texture in granules and flakes; it should be useful also with products intended for soup mixes where piece integrity is desired. However, the effect can be cooked out. Consequently, the treatment may not always work with products intended for remanufacture, or when freezing is employed.

We also know that freezing and thawing cooked potatoes influences texture by retrograding the starch gel (6, 11). In frozen par-fries thawed and held 2 or more days at 45 to 55 degrees F. before finish frying, the starch gel does not as readily hydrate as in those thawed only 1 hour at room temperature (Figures 6 and 7). Texture is adversely affected, and the prolonged holding after thaw also results in greatly increased oil uptake upon finish frying. Although these freezing effects create problems with some products, they are known to have advantageous effects in the manufacture of granules by rendering partially dried, frozen mashed potatoes more friable after thaw so that granulation is readily accomplished.



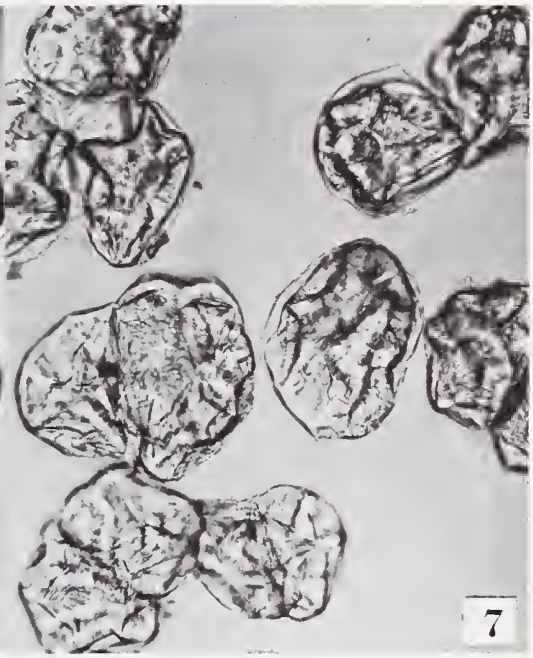


Figure 6. Cells teased from center of frozen par-fried potato, freshly thawed and soaked in water (65 degrees F.) 10 min.

Figure 7. Cells teased from center of frozen par-fried potato after thawing and holding 3 days at 55 degrees F., then soaking in water (65 degrees F.) 10 min. Note shrunken, wrinkled appearance as compared to Figure 6.

The cell wall pectins and hemicelluloses are likewise highly significant structural factors of composition which influence texture. Surprisingly little effort has been made to understand how these substances vary in potatoes since 1934, when Dastur and Agnihotri (2) followed pectic changes during growth and post-harvest storage. This is probably because the orthodox analytical methods do not simulate processing treatments which break down these polysaccharides to varying degrees. Recently it has been found that "hard" cooking tubers, as characteristic of those freshly dug, contain high levels of insoluble pectins and hemicelluloses which prevent ready cell separation upon cooking (12). It was estimated that the effect of these substances may be 10 times as great as the starch gel effect in culinary quality. But the effect is rapidly reduced as the insoluble pectins and hemicelluloses diminish during tuber storage. Little has been published concerning maintenance or manipulation of these polysaccharides for texture controls in potato processing.

Ordinarily, when slices of unpeeled tubers are boiled, cell sloughing begins in the cortex and the inner tissues often do not slough except with prolonged boiling. The cortical tissue is higher in starch and is made up of smaller cells than the perimedullary tissue inside the xylem "ring" (9, 10). The central pith (water core) is the lowest in starch. These differences influence specific gravity and total solids to a marked degree. Specific gravity also is influenced by size and number of minute intercellular spaces between cells, and this may not always have linear relation with solids content in the various tissues and zones of the tuber.

Total solids and specific gravities are compared for bud-end, middle, and stem-end thirds of Russet Burbank potatoes in Figure 8 and of Red Pontiac and White Rose potatoes in Figure 9. There are obvious gradients from outer to inner and from stem-end to bud-end tissues for each variety. But what such data do not reveal is the relative proportion of whole tuber fresh weight and total solids that each tissue and zone comprise. Such data are presented in Table I, on the whole-tuber basis and on the basis of the middle thirds of the tubers.

Obviously, potato products processed in piece form are apt to have undesirable variations in quality between individual pieces, depending upon the numbers of pieces representing lower and higher solids tissues of the tuber, and also upon the degree of difference between tissue zones. Varieties developed for a greater degree of uniformity between cortical and perimedullary tissues, which comprise most of the tuber, would be desirable whether low- or high-solids characteristics are desired. The "all-purpose" potato, if such could exist, imposes a variety of textural problems, depending upon kind of product and desired attributes. As already mentioned, processing manipulation to control desired qualities may not always be successful. It would seem more rewarding to screen varieties, maturities, and storage conditions according to product suitability.

In addition to these interrelationships between structure and texture, within-tuber variation is significant to peeling and trimming loss. When one considers that the high-solids cortical tissue makes up about 1/3 of total tuber volume, but in some varieties may comprise between 40 and 50 percent of fresh weight and total solids of the tuber, peeling depth is very important. Because raw potatoes soak up considerable amounts of water, and water has been used liberally in most conventional peeling methods, the possibility of accurate estimates of fresh weight loss is questionable. The cortical tissues average about 6 mm. in depth in most potatoes. Removal of the outer 3 mm. by trimming and peeling could account for 20 to 30 percent loss of the total solids of the tuber. Much of this loss could be avoided by the newly developed "dry" caustic peeling process (5).

Conclusions

In summary, many of the problems in potato processing directly relate to tuber anatomy and within-tuber variations in composition. This applies not

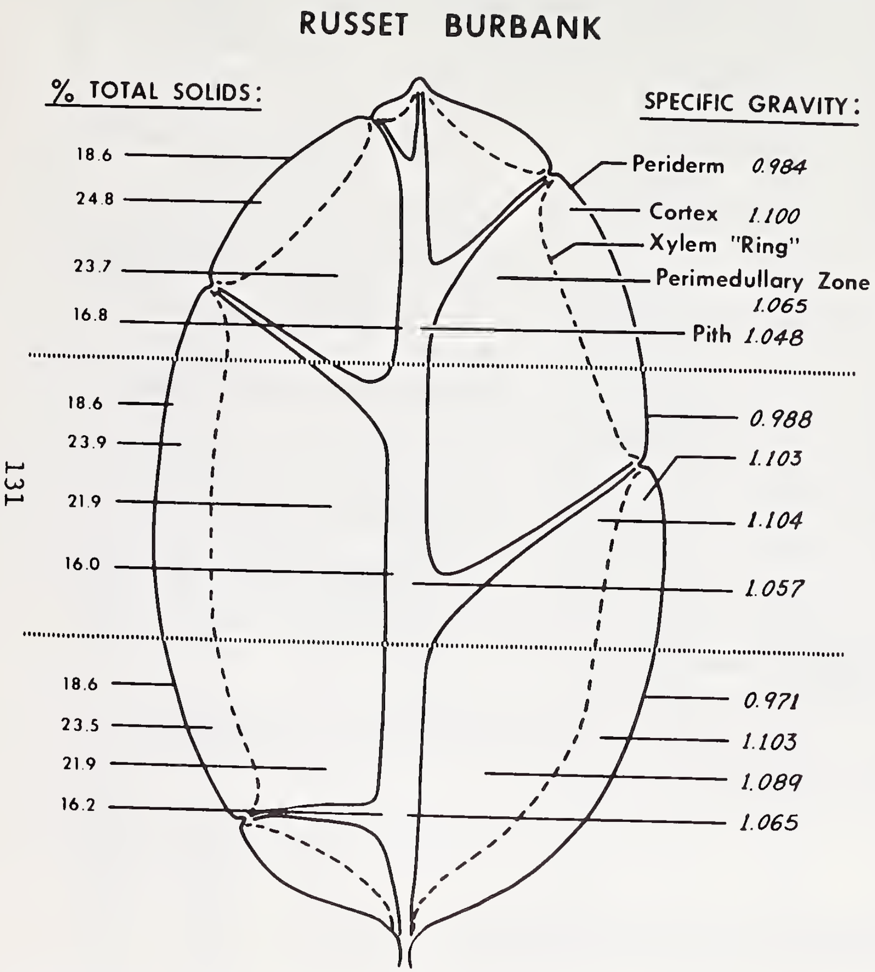


Figure 8. Longitudinal diagram of Russet Burbank potato, showing variations in specific gravity and total solids between tissues and zones of the tuber.

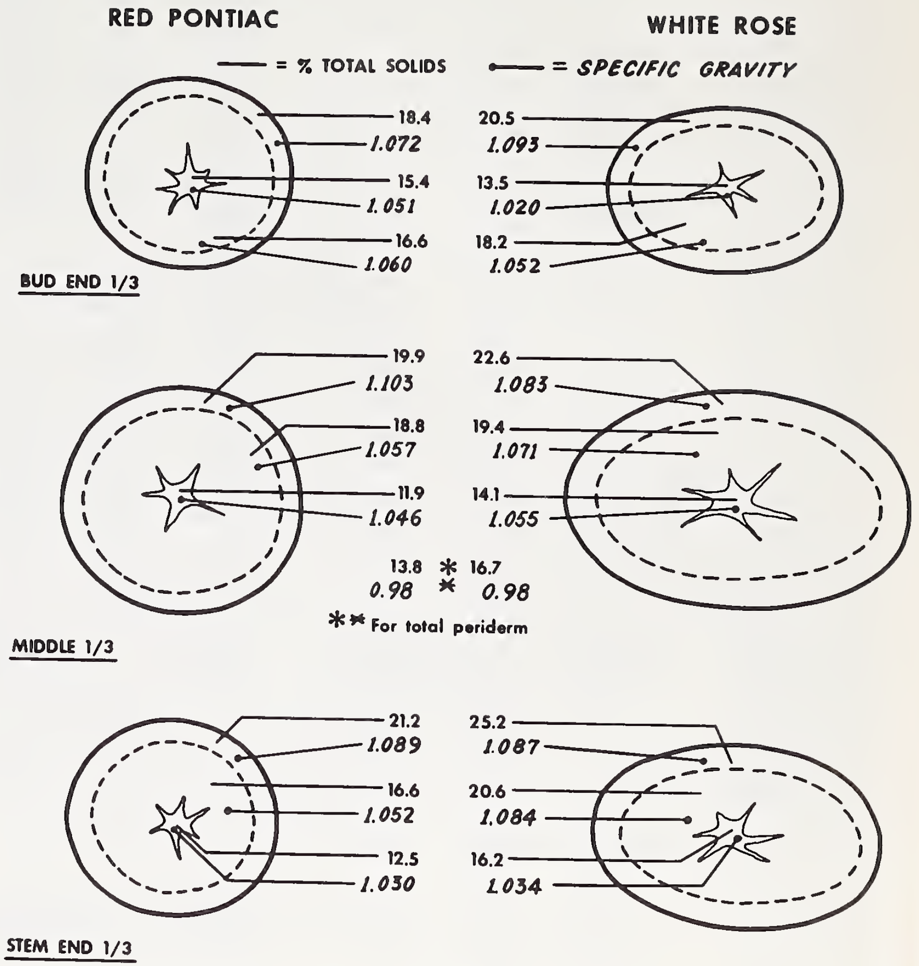


Figure 9. Cross-sectional diagrams of Red Pontiac and White Rose potatoes, showing variations in specific gravity and total solids.

Table I.--Compositional characteristics of three varieties of potatoes based on whole tubers and middle third of tubers

Compositional characteristic	Red Pontiac		White Rose		Russet Burbank	
	Cortex	Perimedullary zone	Cortex	Perimedullary zone	Cortex	Perimedullary zone
Based on whole tubers						
Fresh weight (percent)	37	55	46.4	46.8	42.0	50.5
Total solids (percent)	19.9	17.8	23.0	19.3	23.5	21.9
Total solids of whole tuber (percent)	40.6	53.8	51.0	44.5	44.3	49.8
Based on middle third of tubers						
Fresh weight (percent)	30.8	65.2	44.0	52.0	40.3	56.4
Total solids (percent)	19.9	18.8	22.6	19.4	23.9	21.9
Total solids of whole tuber (percent)	16.1	32.0	21.2	21.3	20.0	25.7

only to the more obvious relationships between structure and texture reviewed here, but also to other compositional variables such as distributions of sugars, phenolics, amino acids, and enzymes. Research devoted to understanding all of these variations could lead to a more successful application of results if the detailed structural variations within potatoes were given greater attention.

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POLYPHENOLS AND OTHER CONSTITUENTS IN RELATION TO POTATO FLAVOR AND COLOR

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Potatoes are grown for food in most countries of the world, although the species may differ somewhat with location. With a yield per acre greater than most crops, the sustaining power of potatoes depends primarily on their acceptability. A variety of high quality should be capable of good yield, but these tubers also should have acceptable cooked qualities of flavor, texture, and color. In this paper we shall deal largely with the flavor and color aspects of potato quality.

Terms used in relation to flavor often cause confusion. In this paper the word "flavor" has been reserved to mean the overall sensation resulting from the impact of food on the chemical sense receptors in the nose, mouth, and throat. Taste is perceived in the mouth by taste buds, and odor is detected by the olfactory epithelium when volatile molecules are inhaled directly through the nose. The complex sensation of taste and odor called flavor is perceived during the eating process as the odorous molecules pass from the mouth to the nose, via the inner passages.

Attempts to relate the flavor of substances to their chemical constitution are probably as old as chemistry itself. The subject is one of complexity, for the palate is very sensitive to what seems to the chemist to be only minor variations in structure. The generalizations that inorganic salts are salty, sugars sweet, acids sour, and alkaloids bitter are not always reliable, and help very little in predicting the taste of the multitude of compounds that do not fall into one of these categories. By focusing on a series of closely related substances,it is possible to perceive relations between their taste and the presence or absence of certain structural features.

As early as 1926,Salaman (11) suggested that the strength of potato flavor was a varietal characteristic, whereas Rathsack (9) considered that the strength of potato flavor was related to the mineral content of the soil, especially the ratio of potassium to nitrogen. Kroner (6) suggested that an inferior taste resulted when excess sugar accumulated in badly stored tubers, and Hilton (4) attributed bitterness to solanine. Kroner and Wegner (7) analyzed an ether extract of the steam-volatile constituents of potatoes and detected an oil containing pentanol, esters, fatty acids, and a high-boiling sulfur compound. Wegner (15) suggested that a phenolic compound was also present in the oil extracted from potatoes in this way.

The almost universal application of gas chromatography to the analysis of potato flavor is evident in the literature in the last few years. In most cases some preliminary separation and concentration of volatiles is brought about by chemical means prior to gas-chromatographic analysis and further confirmation of the identity of individual substances is usually obtained by infrared and mass spectrometry.

Chemical trapping techniques of group separation have been useful for carbonyls and sulfur-containing volatile compounds. Physical trapping techniques which employ cold surfaces for condensation of volatile material have been widely used. The use of programmed gas chromatography has enabled a wide range of volatile substances to be identified.

Self et al. (12,13) and Gumbmann and Burr (3) identified some of the sulfur compounds in the volatiles of cooked potato and found that methanethiol and dimethyl disulfide together constituted 90 percent of the total sulfide. These workers studied four different varieties of potatoes during cooking and concluded that the varieties differed noticeably in their content of volatiles. It is also possible that nonvolatile compounds such as phenols also contribute to flavor.

Phenolic compounds are important constituents related to taste and enzymatic darkening in several different foods (14). Differences in relative astringency of fruits such as peaches and persimmons have been shown to be directly related to differences in tannin or phenolic content (2). Blake and Davidson (1) classified a number of different peach varieties according to tannin content and found some of these so high in tannin that they were regarded as relatively unpalatable.

The phenolic content of potatoes is relatively high, particularly in the periderm and cortex areas, and this has been shown to be a factor of particular importance in enzymatic darkening of potatoes (8). Since potato varieties are known to differ widely in their phenolic content and also in their flavor as well as their tendency to exhibit "black spot," work was undertaken in our laboratory to determine the relationship of phenolic content to certain flavor and color characteristics.

Materials and Method

Source of Material

Potatoes for the study were selected from two main sources: (1) clones that are hybrids between varieties of Solanum tuberosum subsp. tuberosum grown in New York and varieties of Solanum tuberosum subsp. andigenum grown in Peru; and (2) common varieties such as the Red Pontiac, Ontario, and Katahdin. The clones were chosen since it was assumed they would have considerable genetic diversity and offer opportunity for selection of a range of expression of phenols and flavor. The varieties selected have been used in our laboratory for several years because of their diversity of phenolic content and their different tendencies toward enzymatic darkening.

During the first year of the study, 50 clones were analyzed for total phenolic content and were grouped into "high" and "low" categories according to their relative phenolic content. Four clones from each of these groups were selected to be grown and used for the second year of the study. The results of the second year of the study will be reported here.

The clones were grown by the Department of Plant Breeding in experimental plots near Ithaca, N. Y. The three varieties were grown at the Cornell Research Farm in Riverhead, Long Island. The varieties, as well as the clones, were harvested 20 weeks after planting and were stored at 40 degrees F. until they were analyzed for phenolic content and evaluated for flavor.

Determination of Phenolic Content

Total phenolic content was determined using the method of Rosenblatt and Peluso (10) which uses tannic acid as the standard. Four tubers of each group were selected at random for each extract, and duplicate extracts were made for each group used in the phenol analyses. Cortex tissue and the periderm were sampled from bud to stem end of the tuber. A 50-gm. sample was blended with 150 ml. of 95 percent ethanol for 5 minutes. The total extract was measured and filtered, and 35 ml. of the filtrate was used for phenol determinations. Since this method is not specific for phenols but also includes ascorbic acid, corrections were made for ascorbic acid. Potato tissue was extracted with metaphosphoric acid and analyzed for ascorbic acid by the indophenol dye method simultaneously with the analyses for phenols.

Flavor Evaluation

Whole, unpeeled tubers selected at random from each group were boiled for 40 minutes in a 3.5 percent sodium chloride solution. The cooked potatoes were drained and cooled to room temperature, the peels were removed, the cortex area was separated from the pith, and the potatoes were mashed and served to a panel of trained judges.

To determine if phenolic content affected flavor, a Flavor Profile method was developed for analysis and definition of this characteristic. Perceptible flavor notes characterizing the samples were made by each panel member during preliminary testing, and bitterness and astringency were agreed to be the ones most related to phenolic content. Astringency is generally associated with the puckering sensation caused by tasting unripe fruits, and bitterness is associated with the sensation observed on the back of the tongue and in the throat. The intensity of each character note was rated by a panel of 6 trained judges using a 7-point scale of intensity, ranging from 1 (extremely weak) to 7 (extremely pronounced). The judges were selected from a group of graduate students, faculty members, and technicians in the Department of Food and Nutrition on the basis of their sensitivity to the character notes to be studied.

Color Evaluation

A. Fresh samples. For color measurements, the cortex section of fresh tubers was obtained by cutting the tuber longitudinally from bud to stem end. Approximately 200 gm. of cortex tissue was ground in a food chopper using the coarse adjustment and allowed to stand in air for 20 minutes before readings were taken. Color measurements were made using a Hunter color-difference meter. The standard gray tile used for standardization of the instrument had the value: Rd 39.0, a -1.1, and b -3.3. Only Rd values are reported here, since these were most closely associated with potato discoloration as observed visually.

B. Cooked samples. Peeled halves of cooked potatoes were presented to the panel for a comparison of their color with that of five color chips ranging from very dark gray (score 1) to very light or white (score 5). The scale was established so as to resemble the Rd scale of the Hunter color-difference meter which decreases in numerical value with increased darkening.

Results and Discussion

Studies with Clones

A picture of the clones, which were hybrids between North American and South American varieties, is shown in Figure 1. The clones were very irregular in shape, often had unusual bluish or purple markings, deep eyes, and frequently a large and highly irregular cortex.

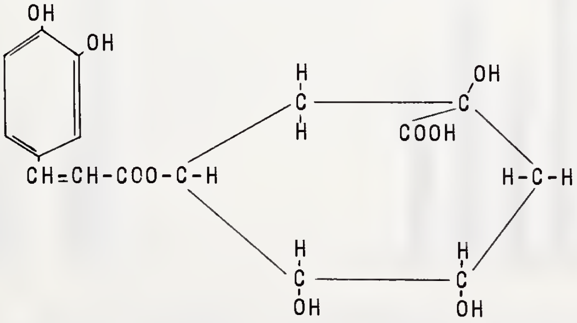
A. Phenols

The eight clones studied during the second year of the experiment were analyzed in the fresh state for phenolic content and were arranged in the order of their decreasing phenolic content (Figure 2). For convenience, each clone was assigned a letter rather than a long numerical designation.

Cooking of the clones resulted in a decrease in phenolic content, as also shown in Figure 2. The greatest decrease occurred in those clones of highest phenolic content, and with the exception of clone C, the cooked clones remained in the same sequence with respect to phenolic content as the fresh clones. The "high" clones showed an average loss of 21 percent in phenolic content during cooking, whereas, the "low" clones exhibited only an 11 percent loss, but the latter continued to have a much lower phenolic content than the "high" group.

B. Flavor

The cooked clones were submitted to a panel of trained judges who scored them for the character notes of astringency and bitterness (Figures 3 and 4). Phenolic content was positively correlated with both bitterness and astringency. The correlation coefficient for bitterness was 0.72 and was significant and that for astringency was 0.82 and was highly significant. The averages of the four clones in each group is given in Figure 5. The judges frequently described a lingering, burning sensation in the throat following the sampling of certain potatoes. Our panelists coined the word "tonsil grabber" for this sensation. The specific phenols involved in flavor have not been elucidated, but we are presently attempting to study these. Chlorogenic acid is one of the chief phenols found in potatoes, and its chemical structure is given below.



Chlorogenic Acid

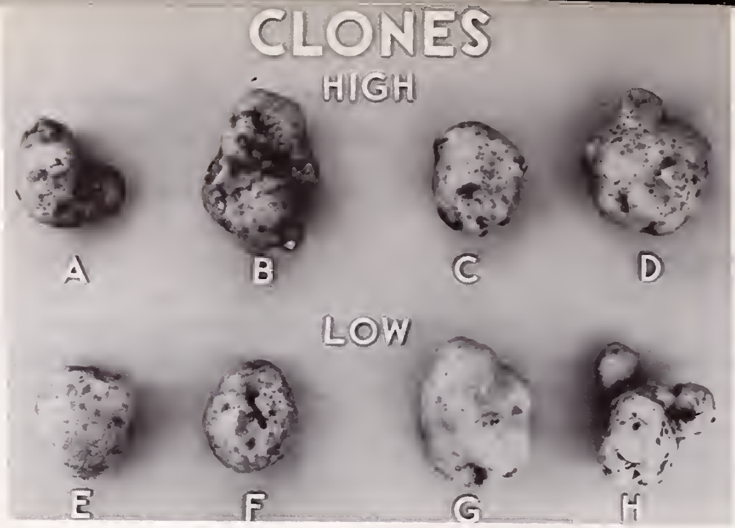


Figure 1. Clones that are hybrids between varieties of Solanum tuberosum subsp. tuberosum grown in New York and varieties of Solanum tuberosum subsp. andigenum grown in Peru. Clones A-D high in phenols; Clones E-H low in phenols.

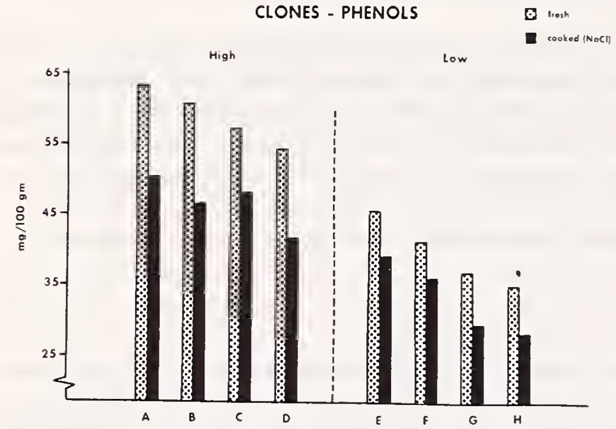


Figure 2. The phenolic content of uncooked and cooked clones shown in Figure 1.

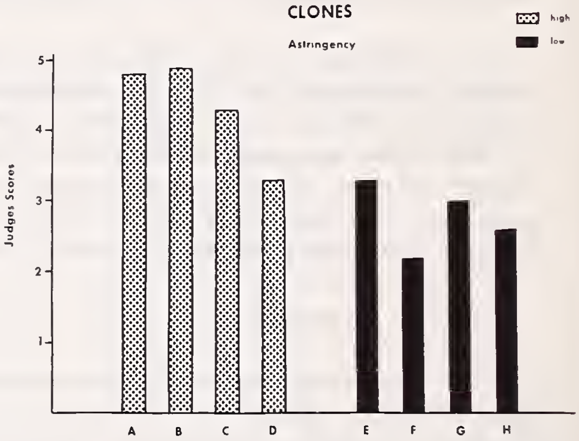


Figure 3. Flavor evaluation for astringency in clones of differing phenolic content. The scale ranged from 1 (extremely weak) to 5 (extremely pronounced).

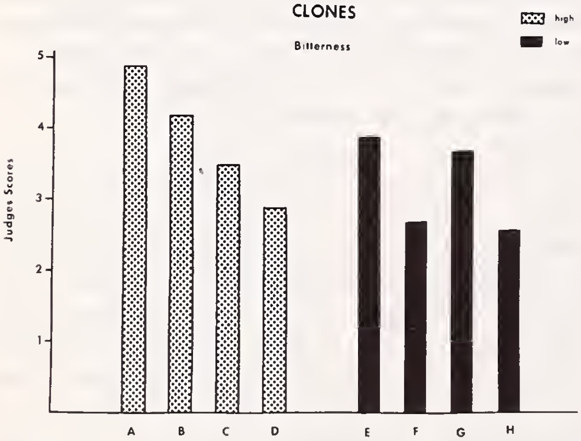


Figure 4. Flavor evaluation for bitterness in clones of differing phenolic content. The scale ranged from 1 (extremely weak) to 5 (extremely pronounced).

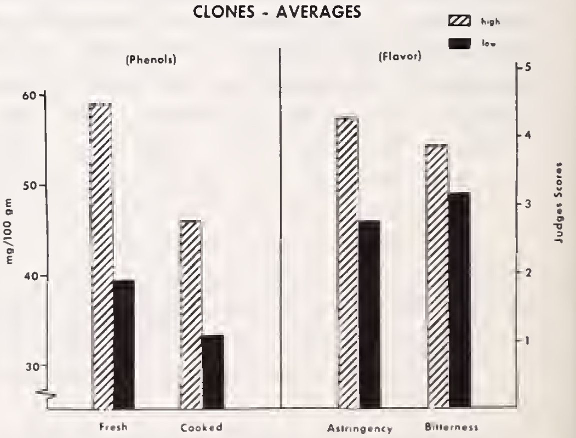
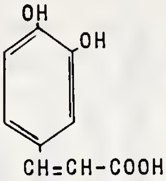
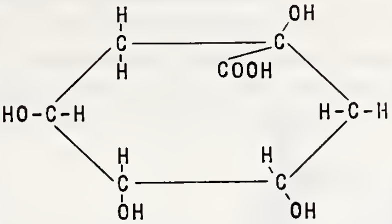


Figure 5. The relationship of phenolic content, both on the fresh and cooked clones, to flavor. Each bar represents the average of four clones in each group.

Upon hydrolysis it yields caffeic and quinic acids, both of which are insoluble in cold water but more readily soluble in hot water.



Caffeic Acid



Quinic Acid

Chlorogenic acid is located largely in the periderm and cortex area and appears to be hydrolyzed during the cooking of the tuber (Figure 6).

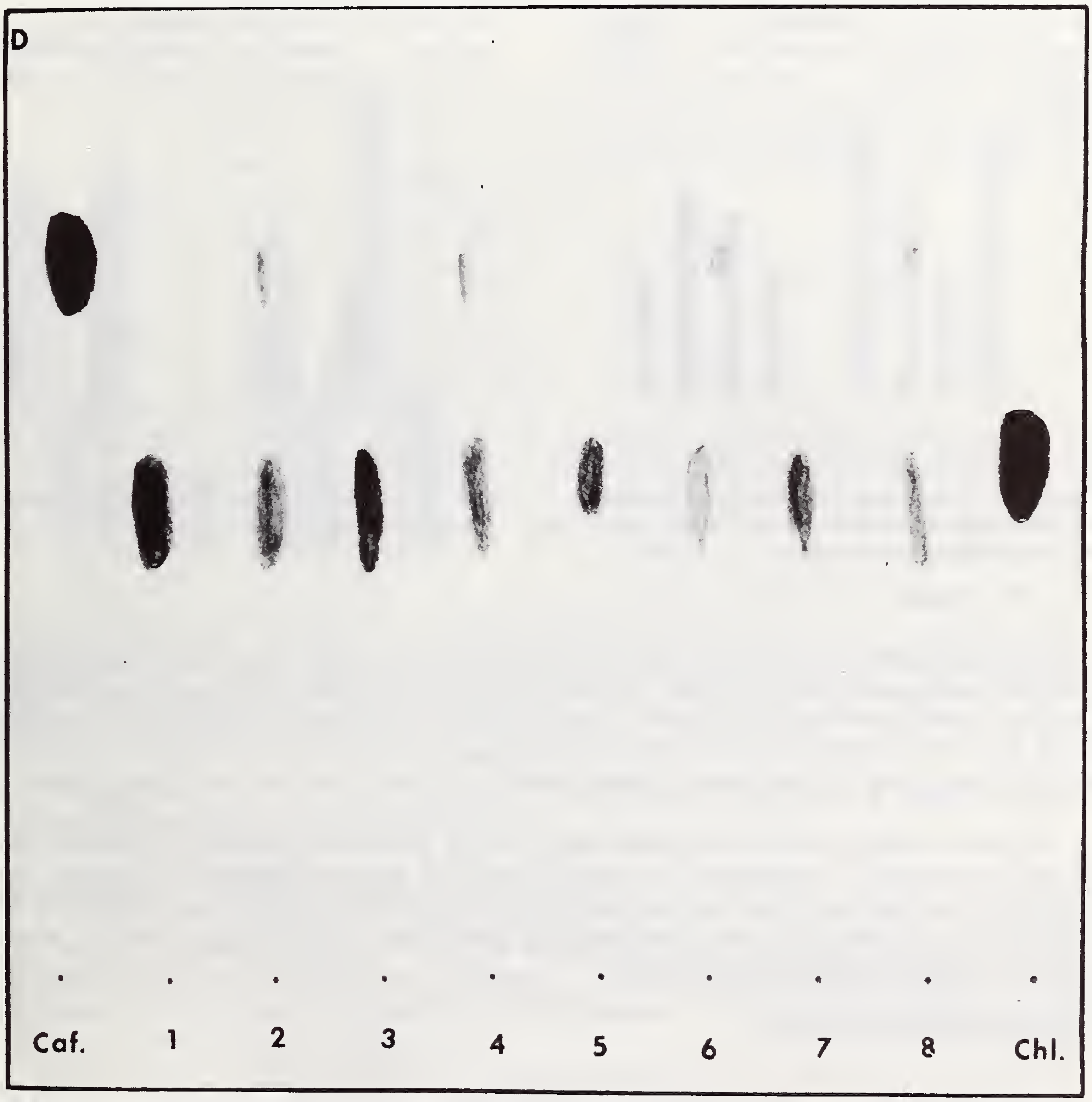


Figure 6. Chromatogram (thin-layer) of alcoholic extracts of fresh and cooked clones which differed in phenolic content.
(1) clone A, fresh; (2) clone A, cooked; (3) clone B, fresh; (4) clone B, cooked; (5) clone G, fresh; (6) clone G, cooked; (7) clone H, fresh; (8) clone H, cooked.

Factors related to bitterness in citrus fruits have been studied extensively (5) and some of the basic chemical structures have been elucidated. The aglycones of all the bitter compounds were found to be nonplanar in shape, whereas in each of the tasteless flavonoids, which one would expect to be bitter, the aglycone portion of the molecule was highly conjugated and planar. Studies of this nature need to be done in the area of potatoes.

C. Ascorbic Acid

The clones that were higher in phenolic content also tended to be higher in ascorbic acid (Figures 7 and 8),but there was great variation within groups and the differences were not significant. The judges were unable to distinguish differences in flavor due to differences in ascorbic acid content.

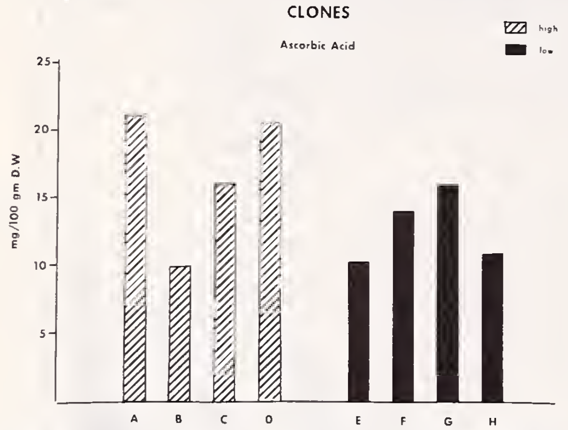


Figure 7. Ascorbic acid content of clones of differing phenolic content. The clones are arranged in the order of their decreasing phenolic content. The terms "high" and "low" refer to phenolic content.

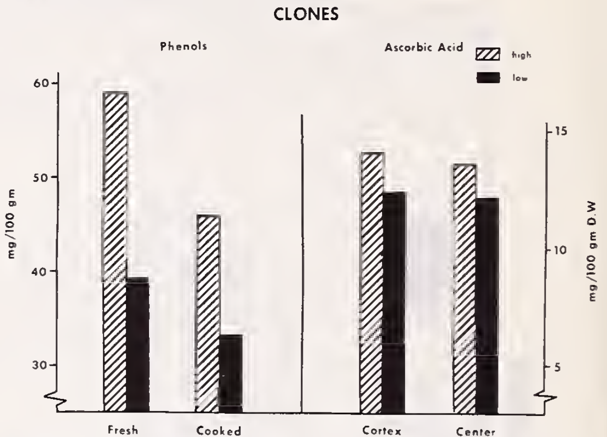


Figure 8. Ascorbic acid content of clones of differing phenolic content. Each bar represents the average of four clones in either the high or low group.

D. Color

Since phenolic content has been related to enzymatic darkening, color determinations were made on the cortex tissue of fresh clones. Increased discoloration (decreasing Rd values) occurred with increasing phenolic content (Figure 9). The correlation coefficient was -0.82 and was highly significant. These findings are in agreement with previous findings in our laboratory.

After-cooking darkening was rated by a panel of trained judges, and although there was a tendency for the clones of higher phenolic content to show greater after-cooking darkening, the differences were not significant (Figure 10). Apparently many factors in addition to phenolic content are involved in after-cooking darkening.

Studies with Varieties

The results of the studies on the three varieties are given in Figure 11. The Ontario variety was the highest in phenolic content, Pontiac the lowest, with Katahdin being intermediate. These differences were highly significant. The same trends were observed in the varieties following cooking, although

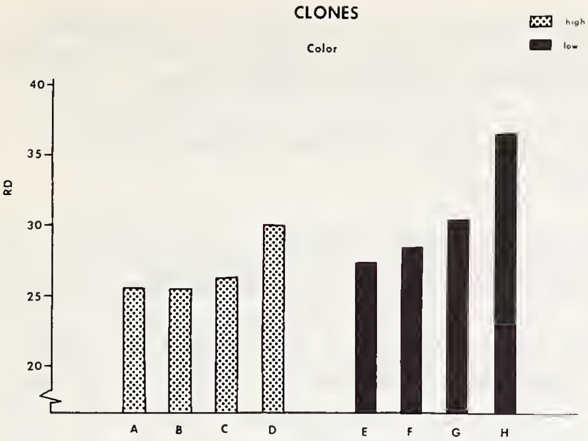


Figure 9. Enzymatic darkening of clones of differing phenolic content. Rd values decrease as blackening increases.

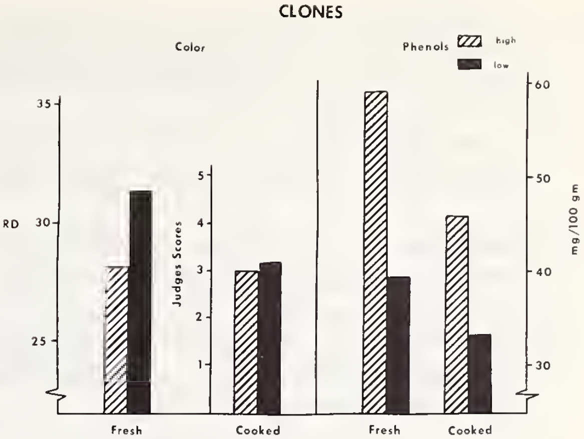


Figure 10. Enzymatic darkening and after-cooking darkening of clones differing in phenolic content. Each bar represents the average of four clones. Rd values and judges' scores on after-cooking darkening decrease as darkening increases.

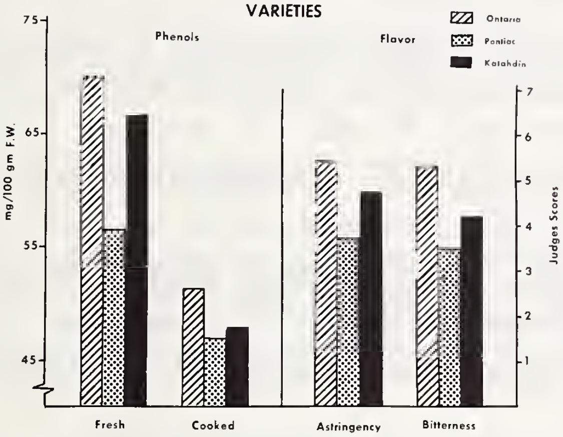


Figure 11. The relationship of phenolic content of three varieties of potatoes, both fresh and cooked, to flavor. Each bar represents the average of 9 determinations on each variety.

the phenolic content in each was markedly lowered by cooking. Earlier work in our laboratory and in other laboratories had shown that the Ontario variety was the most susceptible to enzymatic darkening or "black spot," whereas Pontiac was the least and Katahdin was intermediate.

Flavor scores for astringency and bitterness showed a significant positive correlation with phenolic content.

Comparison of Clones with Varieties

When one compares the studies with the varieties to those with the clones one observes that the clones are generally lower in phenolic content and are scored lower in both astringency and bitterness than the varieties, particularly the Ontario and Katahdin varieties.

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FRYING COLOR OF POTATOES IN RELATION TO TOTAL SOLIDS AND OTHER COMPOSITIONAL FACTORS

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The frying color of potatoes is a major consideration in the selection of raw material for chips and par-fries. Despite a tremendous volume of research relating composition and other variables to quality, no completely satisfactory procedure has been developed for predicting at digging time the performance of potatoes following subsequent storage and handling. The ability to predict storage performance more accurately, and adjust storage temperatures or end use of the crop accordingly, could result in considerable savings to the producer, processor, and consumer.

Since the early work of Thornton (8) and of Patton and Pyke (5), the importance of reducing sugars and amino acids in the browning of potatoes has been generally accepted. Although the practical significance of reducing-sugar content in relation to frying color has been observed by many workers and is recognized in acceptance sampling, storage, and processing procedures, it has been of little value as a basis for predictive procedures. Reducing-sugar content varies at the time of digging and changes rapidly immediately thereafter and in storage, as Porter and Heinze have observed (6). In addition, the magnitude and significance of the relationship of reducing sugar to color has been found to vary by many workers. The practical significance of amino-acid content has not been as thoroughly investigated, although Habib and Brown (1, 2), studying varietal differences in composition relative to color for three seasons, found amino nitrogen and basic amino acids to be significantly related to frying color, and postulated that these might explain inconsistent results with reducing sugar alone.

Studies on composition in relation to frying color were carried out in this laboratory during 1959, 1960, and 1961 with Kennebec, Katahdin, and Russet Burbank potatoes harvested at three different stages of maturity and stored at 70 deg. F. Hogan *et al.* (4) indicated tuber total solids to be more highly related to fry color than total reducing sugar. Whether this involved an indirect relationship to variations in amino nitrogen was uncertain since nitrogen determinations were not available.

In further studies during 1965 with Kennebec and Russet Burbank potatoes stored at 38, 43, and 48 deg. F. for five months and sorted into four specific gravity groups, Hogan *et al.* (3) found that the relationship of reducing sugar to color was nonlinear and that the log function of reducing sugar was more highly related to fry color ($r = -0.93$). Alcohol-soluble nitrogen (which can be considered amino nitrogen) was also found to be related significantly to fry color ($r = -0.50$). The standard partial regression coefficients confirmed these relationships, and showed reducing sugar to be a better predictor of frying color than was amino nitrogen for these samples. Examination of the partial regression coefficients indicated, however, that for a given change in percent composition, amino nitrogen might have more effect than reducing sugar.

Additional tests have been carried out during 1966, 1967, and 1968 with Kennebec and Russet Burbank potatoes, treated with a sprout inhibitor at 50 deg. F. for four months. Prior to evaluation, the stored potatoes were sorted into specific gravity groups at 0.002 intervals. Eight samples (20 tubers each), representing as wide a range in specific gravity as possible, were selected from each treatment for evaluation. Samples were evaluated for fry color, reducing sugar and amino nitrogen (3), and for total solids (4), as cited previously, except that Hunter a readings were used to estimate fry color. The means for data obtained in these tests are shown in Table I.

TABLE I.--Mean values for compositional factors of Kennebec and Russet Burbank potatoes

Variety and year	Total solids (pct.)	Reducing sugar (pct.)	Alcohol-soluble nitrogen (pct.)	Color Hunter a value
Kennebec				
1966	22.83	0.15	0.12	8.9
1967	20.49	0.34	0.13	10.9
1968	23.48	0.13	0.10	7.6
Russet Burbank				
1966	27.34	0.29	0.12	10.6
1967	22.47	0.50	0.14	11.0
1968	22.79	0.25	0.13	11.7

Multiple regression analysis of the overall data showed total solids to have no significant relation to the Hunter a color readings. This variable was therefore deleted from the final analysis.

The following correlation coefficients (all of which were significant at the 0.01 level of probability), r, were obtained:

$$r_{12} = 0.62$$

$$r_{y1} = 0.81$$

$$r_{y2} = 0.72$$

$$R = 0.88$$

where 1 is the log of reducing sugar, 2 the amino nitrogen content, y the color as expressed by the Hunter a reading, and R the multiple correlation coefficient. In these tests the log of reducing sugar was more highly related to color

($r = 0.81$) than was reducing sugar itself ($r = 0.68$). Amino nitrogen was almost as highly correlated to color as the log of reducing sugar. The multiple correlation coefficient, although not as large as desirable, was sufficient for practical as well as statistical significance.

Comparison of the b primes (standard partial regression coefficients) would indicate that for these data the log of the reducing sugar content ($b'_{y1.2} = 0.59$) was a better predictor of frying color than was amino-nitrogen content ($b'_{y2.1} = 0.35$). The partial regression coefficients, however, showed a somewhat different potential effect, changes in percent amino-nitrogen having greater influence ($b_{y2.1} = 33.81$) than changes of a similar magnitude in sugar content ($b_{y1.2} = 4.30$). Correction of the amino-nitrogen values to a protein basis by multiplying by 6.25 would indicate an approximately equal requirement of sugar and amino acids for a given change in color.

The nonlinear relationship of reducing sugar content to color, with decreasing effect of sugar at higher levels, would indicate that amino nitrogen or amino acids may be limiting with regard to the browning reaction. A similar nonlinear relationship was observed by Shallenberger, Smith and Treadway (7) for tubers of much higher sugar content. The relatively small differences in color of many of the samples (Table I) might have been avoided by selecting a higher storage temperature, resulting in a greater influence of variety, season, etc., on overall variability relative to analytical variation and, hence, a larger multiple correlation coefficient.

Results of these studies confirm the findings of Habib and Brown (1, 2) regarding the importance of variations in amino nitrogen as an explanation of discrepancies in the reducing sugar-fry color relationship, and indicate that in some circumstances amino nitrogen may be the limiting reactant in the browning reaction.

It would appear that further attention should be paid to evaluation of varietal, seasonal, cultural, and storage effects on soluble nitrogen in relation to fry color as a possible basis for predicting storage behavior within varieties for a given location.

This research supported in part by Maine potato tax funds and in part by a grant in support of research from Pepsico, Inc.

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INFRARED PROCESSING OF FRENCH-FRIED POTATOES

(Summary)

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French-fried potato strips often become limp and soggy within minutes after they are removed from the fryer. This rapid development of limpness, or "short plate life" as it is often called, is one of the most common complaints registered by restaurant customers and is a major problem for many processors.

To improve rigidity and crispness, many kinds and formulations of algins, gums, and modified starches, as well as calcium salts, have been used as pre-fry dips. These materials improve texture either by coating the surface of the strips with a thin layer of fryable material, or by modifying the surface composition of the strips. Such foreign materials often cook at different rates than the potato tissue, creating serious problems in regulating fry times and keeping the coating material on the surface of the strips. Strict treatment conditions must be adhered to if the technique is to be effective. Success of any specific technique may also depend on the condition of the raw material at the time of treatment. Some treatments work best with young freshly harvested tubers while others are more effective with stored tubers. Air drying prior to frying has also been used.

Another need of the industry yet to be adequately fulfilled is the production of a 3/8-inch square frozen french fry that can be finished in an oven instead of in an oil bath, while still maintaining a crisp outer surface with a mealy baked-potato internal tissue. Such a fry could be baked from the frozen state in a few minutes, eliminating the necessity for the housewife to maintain large quantities of oil for frying and for cleaning after frying. It could considerably increase the retail and institutional market for french fries.

We felt that if a thin crust of gelatinized starch could be rapidly developed on the surface of the french-fry strips, it could be set by only a little par-frying in oil. Then the strips would become rigid and crisp when baked. Infrared irradiation offered a distinct advantage in this regard, in that it develops an intense heat at the surface of the strips without excessively heating the internal tissue.

Procedure for Frying

Fry strips (both blanched and unblanched), 3/8 inch square by 4 inches long, were placed on a perforated steel plate at different distances below the lamps and were irradiated on each of their four major sides for periods ranging from 0.5 to 2.0 minutes. Fry strips were turned by hand. (A mechanized method for turning the fries on a continuous belt will be tested in the near future.) Following the infrared treatment, the strips were fried in oil at 365 deg. F. for 1 to 6 minutes, and then frozen in a blast freezer. Some were finish-fried in oil for 2.5 minutes from the frozen state, and the rest were put in an oven in the frozen state and held for 15 minutes at 425 deg. F.

The height of the infrared lamps above the potato strips was critical in determining the time of exposure needed to develop a very thin layer of gelatinized starch on the surface of the strips. Some drying occurs during infrared treatment; the water loss varied approximately 5 and 15 percent with exposure of 0.5 and 1.0 minute per side, respectively. Percent water loss is inversely proportional to distance between lamps and potato strips. Time of exposure to infrared should be long enough to form a gelatinized layer, but not to cause blistering. For our studies a height of 9 inches above the strips and an exposure of 0.5 to 1.0 minute per side gave greatly improved rigidity to the french-fries, whether finishing was accomplished by baking or frying in oil. When finishing is done by baking, rigidity is greatly improved even with a 1-minute par-fry, but a 2-minute par-fry is better. Improvement in rigidity is greatest with thin potato slices, such as shoestrings, but the 3/8-inch square strip is most popular, and the ability to produce the larger strips is important for expanding the retail market.

Because of the limpness problem, a large part of the frozen par-fries commercially available for baking are the thin size. Certain textural problems are inherent with the use of these fries. If the housewife desires a mealy internal texture, she often must underbake, sacrificing crispness and rigidity. If crispness is desired, overbaking may be necessary. Overbaking produces a thick, crisp layer but causes the internal tissue to pull away from the center, leaving only a hollow shell.

It was also found that in oil-finished fries, as the period of infrared treatment increased, the oil content decreased, regardless of finish frying time. With the best infrared treatment, reduction in oil content was 20 to 30 percent. Infrared treatment to form the gelatinized layer was equally effective on blanched or unblanched potato strips.

In conclusion, infrared treatment of either blanched or unblanched potato strips prior to par-frying increased crispness and length of rigidity, and reduced oil content. Large 3/8-inch square strips can now be baked from the frozen condition, rather than finish-fried in oil, and still have a crisp external crust and a mealy baked-potato texture internally.

THE USE OF GAS CHROMATOGRAPHY AND RADIOISOTOPES TO STUDY TEMPERATURE-INDUCED SUGAR TRANSFORMATION IN POTATO TUBERS

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Introduction

The effect of temperature on changes in sugars in potatoes has been studied extensively since Muller-Thurgau's work in 1882 (5). Several reviews have been published, including those by Burton (3), Talburt and Smith (10), and Smith (9).

Changes in sugars have been followed by chemical analyses such as those of the AOAC (1) or by paper chromatography such as the method of Partridge and Westall (6)

We report here on our use of gas chromatography and radioisotopes to follow temperature-induced changes in specific sugars; to follow the interconversion of these sugars; and to possibly identify other potato components detectable by gas chromatography that may also change with temperature and may therefore be involved as well.

Materials and Methods

Gas Chromatography

We used our previously reported gas chromatographic method (8). Column was 6 ft. by 1/4 in., stainless steel, packed with 3 percent OV-17 on 80/100 mesh Chromosorb W. Temperature was programmed 150 to 250 deg. C. at 2 deg./min.

Radioisotopes

Sugars uniformly labeled with ^{14}C with high specific activity (1 to 2 mc./mg.) were dissolved in water so that 1 μl. contained about 3 μc. Six μl. were injected into the tuber to a depth of 1-3/8 in. After storage at the indicated temperature and time, the tubers were sampled with a No. 6 cork borer and a 1-3/4 in. plug (5 ± 0.1 gm.) was sliced and the sugars were extracted by standard alcohol procedures (1). The alcohol extract was evaporated on a steam bath to about 5 ml. and to dryness with a jet of nitrogen. The dried extract was resuspended in 1 ml. water and 0.01 ml. was spotted in duplicate on Whatman 3 MM paper. Descending irrigation was continued for 44 hours with BuOH-HAc-H_2O (4:1:5). After irrigation, strips were counted on a 4-pi strip scanner with a counting efficiency of about 15 percent.

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After counting, one strip was developed with the alkaline $AgNO_3$ (6) method for sugars, and the other strip was developed with the arsenomolybdate reagent of Hanes and Isherwood (4) as modified by Bandurski (2) for organic phosphates. The $AgNO_3$ is sensitive to reducing sugars, including glucose-6-phosphate and fructose-6-phosphate, and will detect some nonreducing carbohydrates such as inositol and sucrose (sucrose is weak). It will not detect nonreducing glucose-1-phosphate unless the level is high. Hanes-Isherwood reagent is sensitive to glucose-1-phosphate, less so to fructose-6-phosphate. The difficult-to-hydrolyze glucose-6-phosphate is detected by subjecting the treated paper to intense UV or steaming it for 10 minutes.

Activity in the "starch fraction" was determined on a duplicate injected tuber sample. The "starch fraction" was extracted by grinding the tuber sample with water and repeated washing and settling. The "starch fraction" was air dried and a small amount was slurried with water, applied to a strip of 3 MM paper and counted. Some "starch fraction" samples were hydrolyzed at 100 deg. C. in 2 N HCl for one hour, dried with jet of nitrogen and resuspended in water. Aliquots were used for paper and gas chromatography.

The juice was analyzed for pH immediately after grinding the tuber samples.

Results

The changes in fructose, glucose, and sucrose in potatoes when they were moved from 65 to 40 deg. F. storage are shown in figures 1, 2, 3, and 4 for Norchip, Pontiac, Norgold, and Kennebec varieties, respectively. Note that in all cases sucrose was the first sugar to increase (as has been reported often), and it goes through a maximum and actually drops to about one-half of maximum value. Fructose and glucose did not begin to increase until about the ninth day, and the rate of increase was substantially less than that of sucrose. We noted a slight decrease in fructose and glucose up to about the seventh day.

We also plotted the relative amounts of the sugars, as we are interested in their interrelationship. Fructose was always less than glucose and the ratio of glucose to fructose changed without a significant increase in reducing sugars until the end of the first week, when invertase became a factor.

The paper chromatograms and radiochromatograms in figures 5, 6, and 7 show the sucrose, glucose, and fructose activity of potatoes injected at 65 deg. F. with labeled glucose and then stored. In figure 5, showing the effect of three days' storage at 40 deg. F., spots for the three sugars appear in the paper chromatogram, but the major radioactivity is limited to sucrose; the peaks for glucose and fructose indicate only trace amounts of these reducing sugars. There was distinct radioactivity in a spot with an R_f slower than sucrose. This spot coincided with inositol, always present in tubers, though it may have been a sugar phosphate below the level of detection with Hanes-Isherwood; its identity was not determined. Another sugar was present (indistinct in figure) about where glucose-6-phosphate and galactinol (7) should be. This is logical and expected. That this was either or both was not determined. At this concentration, radioactivity was not detected.

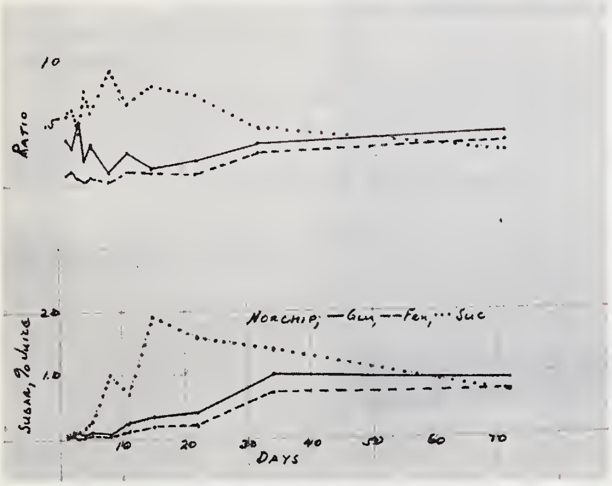

Figure 1. NORCHIP

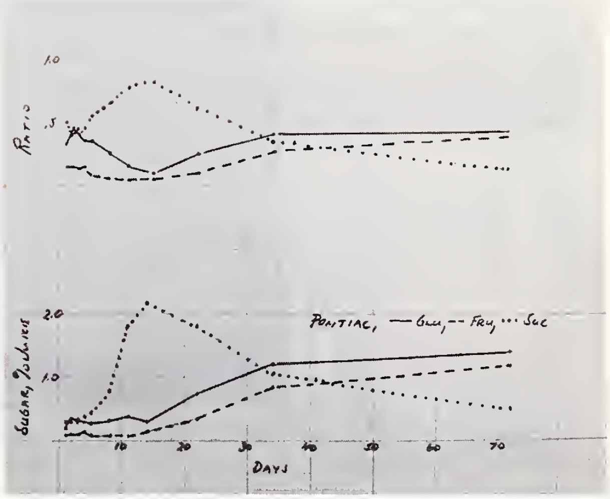

Figure 2. PONTIAC

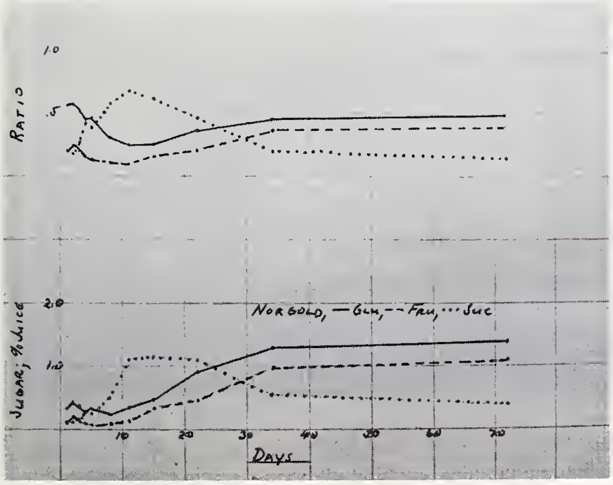

Figure 3. NORGOLD

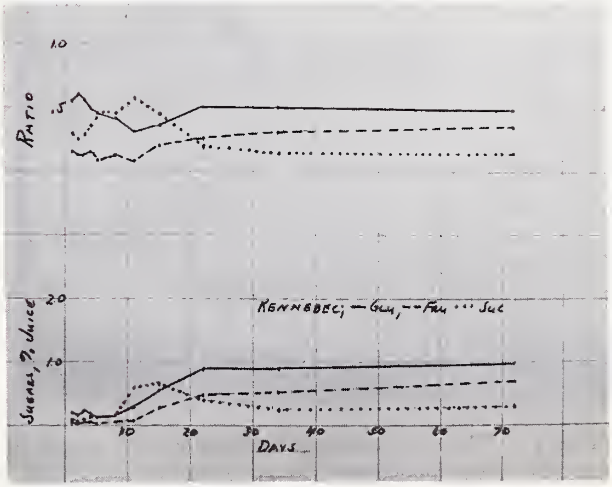

Figure 4. KENNEBEC

Figures 1 to 4. Changes in sugars during storage of 4 varieties of potatoes at 40 deg. F. after initial storage at 65 deg. F. Upper curves in each graph show changes in relative amounts of sugars and lower curves the changes in sugars as percent of juice. Potatoes were harvested September 11, 1968, and stored at 65 deg. F. until start of test on December 2, 1968. Each sample was longitudinal section of 6 tubers.

_________ Glucose; --------- Fructose; .... Sucrose.

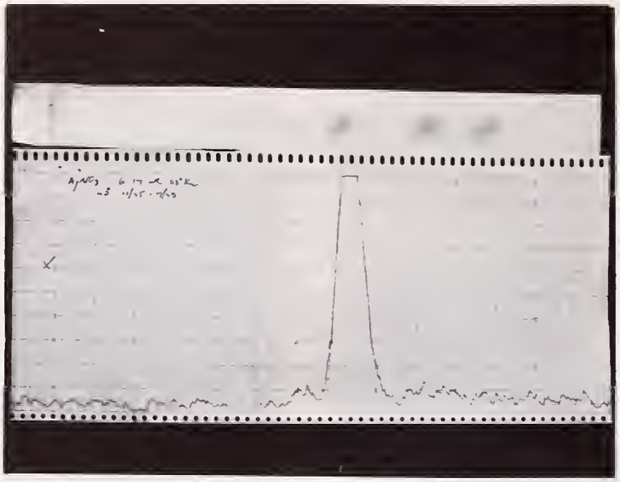

Figure 5. Tubers stored 3 days at 40 deg. F.

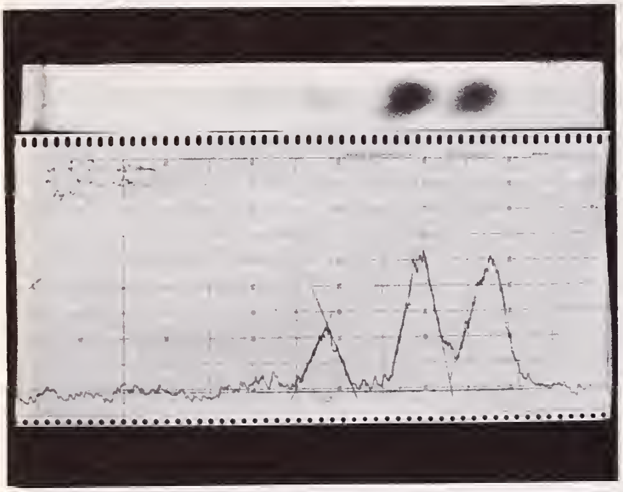

Figure 6. Tubers stored 7 days at 40 deg. F.

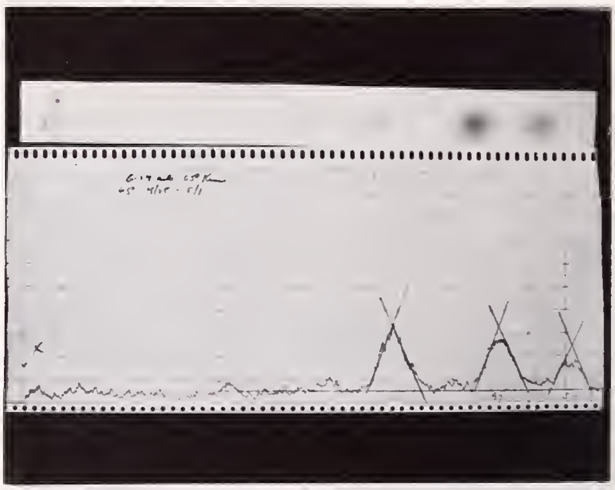

Figure 7. Tubers stored 6 days at 65 deg. F.

Figures 5 to 7. Radiochromatograms of extracts of tubers stored for indicated number of days and at indicated temperatures after injection of uniformly labeled glucose at 65 deg. F. Radiochromatogram settings: range 100, slit 0.5 c., speed 0.2 cm./min., time constant 100 sec. Above each radiochromatogram is paper chromatogram, with spots positioned above corresponding peaks. Principal spots, reading from right to left, are fructose, glucose, and sucrose.

Figure 6 shows results on the same samples after seven days' storage. There is a similarity in the paper chromatograms in that the spots for fructose, glucose, sucrose, and inositol appear, but the fructose and glucose spots are much more prominent. This is borne out by the radiochromatographic curves showing far less sucrose and a striking increase in glucose and fructose activity. The results reflect the action of invertase in converting sucrose to the reducing sugars.

Results on potatoes stored six days at 65 deg. F. (figure 7) indicated less conversion of sucrose to glucose and fructose, reflecting the well-known reduced activity of invertase at higher temperatures.

The numerical data obtained in these and other tests in the series are summarized in Table I.

TABLE I.--Distribution of ^{14}C in tuber sugars

Storage condition*	Form of ^{14}C injected	Form in which ^{14}C is found (c.p.m.): Unknown	Sucrose	Glucose	Fructose	Starch**
A. 3 days at 40 deg. F. after injection at 65 deg. F.	Fructose (U)	0	98	125	0	2x
	Glucose (U)	trace	469	trace	trace	3x
	Sucrose (U)	0	402	trace	trace	5x
B. 7 days at 40 deg. F. after injection at 65 deg. F.	Fructose (U)	trace	16	5	18	3x
	Glucose (U)	trace	18	46	50	5x
	Sucrose (U)	trace	33	4	22	2x
C. 6 days at 65 deg. F. after injection at 65 deg. F.	Fructose (U)	0	98	160	55	52x
	Glucose (U)	trace	117	115	80	27x
	Sucrose (U)	trace	129	96	54	23x

*Kennebecs were stored at 50 deg. F. from harvest in late September 1968. They were treated with a sprout inhibitor (CIPC) and stored at 65 deg. F. at least 4 weeks before use.

**Radioactivity, expressed as number of times the background, of paper strip to which a slurry made of 0.040 to 0.042 gm. of starch had been applied.

Aliquots of the hydrolyzed "starch fraction" of tubers stored six days at 65 deg. F. and seven days at 40 deg. F. all had positive fructose spots on paper chromatograms and fructose peaks on the gas chromatograms. After six days' storage at 65 deg. F., the "starch fraction" hydrolysate from tubers injected with labeled fructose (figure 8) was very strong in activity. There was a slight amount of activity in the "starch fraction" hydrolysate from the radioglucose-injected tubers after six days at 65 deg. storage. Activity in other components was below detection level.

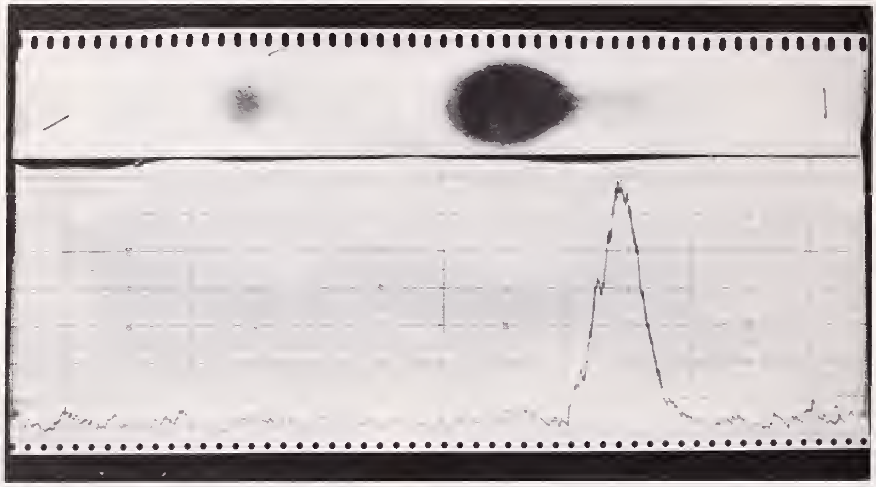

Figure 8. Paper and radio chromatograms of hydrolysate of "starch fraction" stored at 65 deg. F. for 6 days after injection of labeled fructose (Table IC). Radiochromatogram settings same as for Figures 5-7. Large dark spot on paper chromatogram is glucose. Small spot at left (^{R}glucose: 0.4) is probably multotriose. Fructose spot immediately to right of glucose spot is weak, but definitely active.

Only one organic phosphate spot was consistently observed with the Hanes-Isherwood reagents under the test conditions. This spot had an ^{R}sucrose of 1.1 to 1.2 and coincided with dihydroxy-acetone phosphate. No attempt was made to confirm the identity.

The pH of tuber juice varied with temperature of tuber storage, as is shown in Table II.

Discussion

We have evolved a technique using gas chromatography and radioisotopes to follow the sugar transformation in potato tubers. Such a technique closely approximates in vivo studies. It permits applying labeled sugars at specific sites of reaction such as vascular area, pith, etc. By use of sugars with high specific activity, the amount applied may not cause a local concentration unbalance.

Some typical data have been presented. While far from yielding firm conclusions, they do make us aware of other possible reactions. For example, consider the activity in a spot coinciding with inositol (figure 5). Inositol is formed from direct cyclization of G-6-P. Rapid incorporation of labeled glucose into inositol implies that inositol has a dynamic role in sugar transformation. Also consider the high level of activity in a fructose isolated from the hydrolyzed "starch fraction" (figure 8). Although contamination was

TABLE II.--Effect of storage temperature on pH of potatoes

Variety	Storage conditions	pH of individual tubers
Pontiac	Initially (40 deg. F.)	5.91, 5.94, 5.91, 5.93, 5.95
	3 days at 65 deg. F.	6.06, 6.49, 6.11, 6.15, 6.14
	4 days at 65 deg. F. plus 2 days at 40 deg. F.	5.84, 5.91, 5.89, 5.91, 5.89
	6 days at 65 deg. F.	6.06, 6.13, 6.11, 5.65
Kennebec	Initially (40 deg. F.)	5.79, 5.75, 5.73, 5.74, 5.70
	2 days at 65 deg. F.	5.81, 5.77, 5.81, 5.74, 5.79
	2 days at 65 deg. F. plus 3 days at 40 deg. F.	5.71, 5.72, 5.71, 5.67, 5.68
	5 days at 65 deg. F.	5.77, 5.78, 5.74, 5.76, 5.76

not ruled out, the repeated washing of the "starch fraction" should have removed its soluble fructose to the point where activity would be low. Thus one suspects that a fructose polymer is also involved in sugar transformation.

There is a small change in tuber pH (Table II)in changing storage temperature between 40 and 65 deg. F. Such change precedes any detected change in the principal sugars, but one cannot say that pH is a response to temperature change, followed by sugar changes. More precise data are needed before any statement can be made.

Acknowledgments

The technical assistance of Mrs. Karon Miller is gratefully acknowledged.

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RESEARCH IN THE POTATO-CHIP INDUSTRY*

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When I was invited to speak to this conference on research in the potato-chip industry, the main problem was immediately apparent--i.e., to be able to sort out from our many research activities those items which would be of particular interest to the potato utilization group. Through correspondence with Dr. Treadway, it was finally decided that a sort of polygraph view might be in order. For this reason, the talk is divided into several sections and deals with more than one topic.

Color Control in the Potato-Chip Industry

Throughout my long experience in the chip industry, color control has been its most serious problem. Early in our research we were able to determine the cause, as well as time and temperature relationships, of color development in the product. The problem became one of finding the best way to control the browning reaction, and the problem continues today.

Our company has long believed in potato breeding as a means of controlling potato chip color. Varietal selection seems to offer great promise. Some recent research by our group has indicated that certain varieties of potatoes contain various quantities of invertase inhibitors. These inhibitors seem to reduce greatly the production and subsequent level of glucose and fructose, which of course are two of the sugars which enter into the browning reaction. We have operated a breeding program in our company since 1956. Many of you are familiar with the content of this program.

We have a greenhouse in Madison, Wisconsin, and a research farm and greenhouse in Rhinelander, Wisconsin. We also have acreage in Alabama, Florida, and North Dakota for field trials. In addition, we conduct field trials in ten or more potato-growing areas each year. Our best entries from the research program in Rhinelander are shipped out to these areas and the clones are observed under commercial growing conditions. We feel that we have made good progress in this program, and a significant amount of our supply this growing season will be made up of varieties that have come from our potato-breeding program. The main objective of this program has been to select those varieties that produce light-colored potato chips. We, of course, have also been interested in the aspects of yield, disease resistance, water tolerance, shape, and other characteristics important to the grower or the chipper.

A recent process for controlling color in potato chips has involved the use of microwave energy. Our company has studied the process extensively and has accumulated large quantities of data which give us good insight into the mechanics of this process. Strangely, the big "hang-up" with microwave processing has been equipment performance and reliability. We have, ourselves, purchased two large commercial units and have done considerable testing with them. The principle by which the process is expected to work is based on preferential absorption of microwave energy by the residual water in the potato chips. This should be accomplished without heating the product excessively so that objectionable browning is avoided.

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*Presented by Dr. William L. Beale, of Frito-Lay, Inc.

In practice, the chips are removed from the frying machine with approximately 6 to 7 percent residual moisture content. They are then passed to the microwave oven to reduce the moisture to 2 percent or less. A strong supply of warm air is provided to evaporate the water. The temperature of the air is maintained at about 220°F. or less. This evaporation cools the product and prevents overheating by the microwave energy. The frequencies we used were in the range of 915-925 megacycles. Under these conditions, fat is quite "lossy" (absorbed), and the drying air is needed to prevent the product from overheating.

There is no question that the color of potato chips can be improved considerably through the use of microwave energy. However, there are several problems associated with the process other than mechanical. The foremost problem is the variability of sugar content of potatoes within a given lot. If this variability is extreme, there will be some dark chips because of the temperature rise of the product within the oven. These must be removed by hand after processing.

A second problem is in the auxiliary equipment. The potato chip fryer must be perfectly balanced so that the product at exit is of uniform moisture content from side to side. In conventional practice, a moderate amount of moisture variability can be tolerated, because the color will equilibrate as the product leaves the fryer. Early removal, however, through the use of microwave energy, does not allow time for this equilibrium to be established. Therefore, if the machine is out of balance, variability in the finished product seems to be accentuated.

Another problem may develop in balancing the auxiliary equipment to the microwave oven so as to avoid overpowering the unit. Most microwave ovens have approximately 50 kilowatt hours of microwave energy available. The coupling efficiency of some units would tend to reduce the power actually absorbed by 50 percent or more. As you can see, it is easy to overload a unit of this size by supplying more chips than the available power can accommodate. Other problems involve maintenance and cleaning of the equipment, mechanical upkeep of the attendant apparatus, avoidance of bending wave guides and power-handling devices, as well as many others.

Assuming reliable mechanical equipment, the question as to whether microwave energy should be used for color control of potato chips would ultimately revolve around the economics of the process. By this I mean the gain in potato savings versus the added cost. I am sure it is well known that most of the loss of potatoes is caused by the warm storage required in order to avoid the accumulation of reducing sugars and subsequent chip browning.

Potatoes to be processed with microwave energy could be stored at lower temperatures to avoid rot, shrinkage, and sprouting, because of the higher reducing-sugar content that can be tolerated. Another advantage would be that good quality chips could be produced from some potato lots that otherwise would have to be resold or dumped. Occasionally a lot cannot be cured or fails to reach the level of reducing sugars required for conventional processing.

However, these gains must be considered in light of the cost of microwave processing. The major costs are: capital depreciation on the equipment, power and personnel to operate the unit, and maintenance and upkeep. There are other incidental expenses such as floor space occupied. All of our information to date indicates that the economics, while not exciting, are reasonable, provided an efficient microwave oven could be fabricated that would be reliable in its operation and relatively maintenance-free. This assumes, of course, that all the other problems mentioned in this paper, such as auxiliary equipment proficiency, would be overcome.

Extruded Potato Snacks

The industry has been excited from time to time by the entry into the marketplace of various types of extruded potato snacks. There is no need to mention these by name, but I am sure most or all of them are familiar to you. In our company, we have been very much aware of their possibilities for many years. In fact, I have been engaged in a program of investigation and research on them since 1959. We have obtained several patents, both domestic and foreign, covering certain processes developed by our company. The formation of the potato snack is usually through some form of extrusion or sheeting and die-stamping. The advantages of such a product are readily apparent. One can obtain uniform size, color, and shape, and avoid most of the problems of raw-material handling and storage. This is made possible through the use of predried potato flakes or flour in place of fresh potatoes. The economics of such a product are reasonably sound. They are based on the freight saving that can be realized since fresh stock does not need to be shipped from the larger growing areas. Another advantage is the price-leveling effect of a processing outlet that tends to eliminate the wide variation in the supply of fresh potatoes throughout the year and throughout the various growing regions.

As with any development, however, the problems solved through a new process are often replaced by new problems which may be as difficult to solve as the old ones. It is my feeling that the principal question related to extruded potato snacks is whether or not the public is willing to accept such a product as a replacement, or partial replacement, for potato chips.

These are questions currently being answered through several market tests under way in the United States. It is also my belief that the ultimate success of such a snack will depend on the ability to supply a product that will satisfy the consumers of the largest-selling snack item--namely, potato chips. You can be sure that my company is carefully watching developments, and if our studies indicate the need, we shall be able to supply such a product.

Fats and Oils for Snack Frying

Most basic research in fats and oils has been done either by the manufacturers themselves or by various Government laboratories. Since I entered this industry 18 years ago, developments have been remarkable, especially in the use of certain oils which I would class as linolenic. Of course, the principal one would be soybean oil, which is extracted from a crop grown principally for its oil content. Most other frying oils are byproducts. Serious attention has been given to the processing and upgrading of soybean oil to make it suitable for frying use. Various manufacturers have seemed to overcome the major problems of flavor reversion and are providing good frying oils based on the soybean product. I don't know of any chip manufacturer that uses soybean oil alone, but many use it in combination with the other oils. It is my personal belief that cottonseed oil, when processed properly, provides the best flavor in the processed chips.

Other oils widely used have been corn and peanut. Recently there has been some interest in high oleic safflower oil and in sunflower oil. Also, there have been some new processing techniques developed, such as solvent extraction. This technique allows the production of oils of high stability and subsequent long shelf life. Our principal research in this area is to constantly survey developments as they occur and to recommend to our company the best combination of these oils to meet its frying needs.

Mechanical Research

We have been heavily engaged in the design and fabrication of various mechanical devices for making our present products as well as new ones. In some processes the extruded products require long and tedious drying conditions. It is quite a challenge to design and fabricate apparatus which will provide a reasonable output and yet provide this tedious drying environment. In one of our laboratories we have pioneered the development of such a dryer and have achieved remarkable results. The dryer is rotary for the purpose of keeping the product in motion and, at the same time, providing positive through-put. This is quite a trick when you consider the drying time and space requirements for some of these extruded products.

Other types of research have been the design and fabrication of larger frying units for some of our snack products. We have developed one fryer with a unique heating provision. The twin-tube heat exchanger is capable of supplying more than enough heat to evaporate the water. At the same time it is open-ended, with plugs in each end of the line. This provides ease of inspection, cleaning, and maintenance. The heat exchanger is capable of withstanding 2000° F. and is fabricated from a unique alloy which provides the necessary resistance to this high temperature. The unit is easily capable of producing 2000 pounds per hour of the snack for which it was designed.

In the area of extrusion apparatus we have conducted considerable research. We have extruders that vary from bench size, handling 5 to 10 pounds of product per hour, up to and including a device capable of extruding over 1500 pounds of raw dough. In contrast to the cereal industry, which of course has had many years' experience with extrusion, our industry has had limited exposure to this technology. We have had to acquaint ourselves with it rapidly so as to take advantage of the possibilities for extruded snacks.

Conclusion

In summary, our industry is active in conducting research toward the solution of its problems. We have many fine research people and many fine companies actively seeking to provide better snacks and to expand their usage through better quality. I feel very comfortable about the future of snack foods. In the first place, they represent fun and good times to the consumer. This almost ensures a continuous and growing market. Secondly, our industry is maturing, and we are paying the price necessary to attract good scientific workers who can continue to provide upgraded quality and new products to satisfy this expanded market.

RESULTS OF A FIVE-YEAR PROGRAM FOR EVALUATING NEW VARIETIES OF POTATOES FOR CHIPPING

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Introduction

Variety selection by a grower is one of the most important aspects of his production program each year. The selection of the variety or varieties should be based not only on yield and adaptability to his area of production, but, more importantly, on the market acceptance of the variety. This is determined more and more by the processor's use of the grower's efforts. The processor can make certain adjustments during production to offset inferior raw-product attributes, but he knows his biggest single variable is the raw product. Without question, the variety is the first emphasis when considering the raw material. Therefore, when one considers research in this area, he must look at the variety problem from the view of both the grower or producer, and the processor. This may be a topic for arbitration, but it appears that the processor's use of the grower's product should influence the researcher in potato breeding and in the development of new processing practices.

Methods

Although this study has been conducted for a number of years, we are only covering here data collected during the past five years, since new varieties are constantly being developed.

Each year, up to twelve varieties were replicated twice on each of four to seven farms located throughout the state of Ohio. Planting data ranged from early April to late June depending on the year. The seed in most cases was cut just before planting and was treated with a fungicide. Yield records were made on all plots.

Each grower employed his usual farm practices for fertilization, cultivation and spraying. Some of the growers had irrigation systems and used them when applicable.

Potatoes were graded immediately after harvest with 25-lb. samples from each plot removed for processing. These lots were delivered as promptly as possible (no more than one week elapsed between harvest and processing during the years) to The Ohio State University pilot processing lab. Upon receipt at the processing laboratory, an 8-lb. sample was removed from each lot for specific gravity measurement (NPCII Hydrometer Method) and the number of tubers per eight pounds was recorded.

The 25-lb. sample was sub-sampled with three pounds removed for immediate manufacture into chips and the rest was placed in 55 deg. F. storage. After three months, the lots were removed from storage, and a 3-lb. sample was manufactured into chips at intervals of 1, 10, and 20 days (20-day intervals were used only in 1964 and 1965) after reconditioning at 70 deg. F.

The chips were manufactured after first being peeled in an abrasive peeler for 30 seconds, sliced in a Littrell slicer set for 18 slices per inch, and washed in cold water. Two 1-lb. samples were removed (no slivers or small pieces were used). The lots were fried in peanut oil (the free fatty acid did not exceed 0.5 percent) using The Ohio State University continuous chip fryer. For these studies the inlet temperature was held at 375 deg. F. with the discharge temperature at 355 deg. F. The fry time varied from 45 to 55 seconds depending on the specific gravity of the chips as indicated by finished chip moisture content, which did not exceed 2-1/2 percent.

Following frying, the yield of chips was recorded, the samples were matched to the NCPII Coughlin Color chart in a MacBeth Examolite. A sub-sample of each chip lot was placed in a Waring Blendor bowl and ground in the Blendor for 30 seconds. The sample was removed from the bowl and placed in the Agtron F cup and Agtron color was read directly after standardizing the instrument at 30 with gray disk (Agtron 30).

Results

The results are summarized in the following tables by variety, year, and grower for each of the attributes evaluated.

Four varieties (Katahdin, La Chipper, Ona and Superior) were used all five years; three varieties (Kennebec, Monona and Sebago) were used four years; three varieties (Arenac, Haig, and Snowflake) were used three years; five varieties (Cobbler, Lenape, Pennchip, Platte and Penobscot) were used two years; while 19 varieties (ND 4192-3, Fundy, Early Chippewa, Russet Sebago, Pungo, Plymouth, Avon, Red La Soda, Teton, WY 1122, Norgold Russet, Chippewa, Russet Burbank, Norchip, Norgold, Hi Plains, Red Pontiac, Alamo, and Peconic) were used only one year.

The summarized tabular information indicates three main variables among the data: (1) varieties, (2) years, and (3) growers. The four attributes measured were percent yield, specific gravity, Coughlin Color, and Agtron F color.

In general, yield values positively correlated with specific gravity while Coughlin Color scores were negatively correlated with Agtron F color values.

The best variety in terms of yield and specific gravity was Arenac while the poorest was Monona. On the other hand, Monona had the best color, while Ona had the poorest color. Variations among the years showed the best tubers were grown in 1964 and 1966 with the poorest crop production in 1965. The 1967 and 1968 crops were in between these extremes.

Grower differences were quite large among the varieties, but not among the years.

Some of the higher-rating varieties are Arenac and Monona. The following varieties were of average quality for one or more attributes: Ona, Katahdin, Sebago, Kennebec, La Chipper, Superior and Haig. Snowflake was acceptable only before storage. The other varieties were not in the study long enough to make recommendations on their performance.

In conclusion, potato varieties for processing must be evaluated from more than one producer and over three or more years. Further, evaluation before and after storage is important if the product is to be processed, at least for chips, after storage. Specific gravity is a good indicator of yield and Agtron F color is a more reliable index than Coughlin Color.

NOTE: Detailed data for this study are avilable from Dr. W. A. Gould, Head, Department of Horticulture, Food Processing and Technology Division, Ohio State University, Columbus, Ohio 43210. Ask for Multilith Report No. 360.

POTATO PRODUCTION AND PROCESSING IN MICHIGAN

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On behalf of my company, I am honored to have been asked to address this distinguished group. My topic is potato production and processing in Michigan. Needless to say, potato production and potato processing each have been the subject of many books, and I assume of several of the presentations to be made at these meetings, and to do more than barely touch on them in the few minutes we have is an impossible task. Besides, I am not a specialist in either production or processing. I therefore think that a brief discussion of how Ore-Ida got to Michigan, of how we feel about being here, and of some of the problems and opportunities we see in Michigan may be the best use of available time.

Ore-Ida has been in the potato-processing business for nearly 20 years. We first became interested in Michigan as a potato-processing area in 1964. The frozen-potato industry was growing rapidly and Ore-Ida had been getting more than its share of the growth. Production capacity was a continuing problem for the company and, although this problem had been answered in 1960 and 1964 with the addition of two plants in Idaho, the need for more capacity continued. Unfortunately, I learned at noon today that we are again faced with this problem as a result of a serious fire that is still burning at our Ontario factory. Our western plants, though producing a quality Idaho product, restricted us in competing effectively for the significant frozen-potato market in the major population centers of the east. Our distance from these markets gave processors from areas such as Maine a distinct competitive advantage because of the difference in freight costs. We therefore began to investigate potato-growing areas located closer to the eastern markets--Minnesota, Wisconsin, Illinois, Indiana, Ohio, and Michigan were among the States we considered. All of these areas were within a 200-mile radius of one-fourth of the nation's population. All were capable of producing the variety of potatoes we required for processing.

We finally decided on Michigan principally because the freight advantage to New York and other eastern markets was as good as or better than the other areas under consideration and because of Michigan's past record as a potato-producing State. As Governor Romney said at the dedication of our Greenville factory in 1965, "Forty years ago Michigan grew more potatoes than Idaho does today."

The decline of Michigan as a potato producer was examined carefully. It appeared that it was triggered initially by a lack of dependable rainfall which resulted in reduced yields. But with the development of efficient irrigation systems, this problem could now be solved. Lands that once produced quality potatoes had been allowed to run down and were no longer suited for quality potato production--but good rotation practices could solve this. Then in the 40's a blight problem took a heavy toll--but improved fungicides could and were alleviating this problem. It was these problems, combined with the declining fresh-potato consumption in this country and the increased competition from States like Idaho and Maine, that moved Michigan from the No. 1 potato producer as late as 1943 to a low position in the top 10 by the mid-60's. Potato production in Michigan had dwindled to the point where it was no longer a prime factor in the agricultural economy of the State. The heavy industrialization of the State compounded the potato problem as more and more farmland was left fallow in favor of more secure, higher paying industrial jobs. Michigan potato acreage had declined from a high of 365,000 acres to less than 40,000 acres. No State has ever grown the quantity of potatoes that Michigan once did. Ore-Ida had thus selected a plant location which would require it to participate in pioneering a rebirth of the Michigan potato industry.

The problems that led to the decline of Michigan as a potato-producing State became the opportunities for this rebirth. The soil was there with water for irrigation. History had proved that Michigan could be a major potato-producing area. This was underscored by some of the growers who continued to produce in Michigan over the years. The sought-after freight advantages were there. Michigan seemed a reasonable place to build a plant.

The principal initial problem Ore-Ida encountered was to find growers who were willing to grow a variety of potato that was relatively new to them--the Russet Burbank--in a volume sufficient to supply our factory needs. This variety, because of its uniform high solids and its storability, is, in our opinion, essential to a processing operation. Although many local growers responded favorably, we ultimately found it necessary to participate in moving some western potato growers into the area. This meant buying and leasing farmland so they would have a place to farm--and it meant becoming involved in financing some of these growers. We had intended to enter Michigan only as processors, but suddenly found ourselves deeply involved in farming. By the fall of 1965 the Ore-Ida factory was completed and the first crop of Michigan-grown Russets was being processed into frozen french fries.

What has been the impact of the introduction of frozen-potato production in Michigan? An examination of available data discloses that what happened in this State is a miniature of what occurred several years ago in the total potato industry with the advent of potato processing. Nationally, per-capita potato consumption had been declining. Sales of fresh potatoes were dropping. As processing emerged, the trend was reversed and per-capita consumption increased for the first time in years. In the 10 years prior to Ore-Ida's involvement in Michigan, potato acreage here declined steadily to a low of less than 40,000 acres in 1964. With the addition of the new market for raw potatoes that freezing has brought to Michigan, the trend here has also been reversed.

Another result of the introduction of potato processing into the Michigan agricultural scene has been a shift in variety selection. Russet Burbanks now constitute nearly 25 percent of Michigan's potato production. As late as 1964 this variety was last among the four varieties that account for over 80 percent of this State's production. Now it is first. Montcalm County, Ore-Ida's principal source for potatoes, is the State's leading producer of potatoes, and nearly one-half of these are now Russet Burbanks.

I said earlier that I would tell you how we feel about being in Michigan. In so doing, I think candor is in order. Both our interests and the interests of Michigan agriculture can best be served if we can speak frankly about our problems. Our principal areas of concern about Michigan as a frozen-potato processing State are:

1. Cost of raw product,
2. Cost and availability of an adequate supply of labor, and
3. Selling price of Michigan-produced finished product.

First, cost of raw product. The price we pay for raw potatoes in Michigan is higher than in any other area in which the company operates. This is a major concern to us as a processor because the amount we pay for raw potatoes represents nearly 40 percent of our cost of goods sold. Among the factors affecting the cost of Michigan raw product would appear to be the high cost of agricultural labor and the need for more extensive fungicide programs than normally. We also believe that the lack of a reliably profitable rotation crop or alternate cash crop contributes to this high cost, in that potatoes must absorb a disproportionately high percentage of a grower's overhead. But, regardless of the reason, production costs per unit are clearly high and steps must be taken to reduce them if Michigan producers are to compete effectively. Perhaps the answer is in the development of a new variety that is higher yielding, or blight resistant, or both. Maybe we simply need another good crop to help pay for the land. In any event, high costs represent a challenge to us as a processor and to any other group interested in the future of Michigan as a potato-processing area. It certainly is a matter that should be of concern to the university and extension personnel in the State. Even though the quality of Michigan raw product is excellent, it is difficult to compete effectively with areas where the cost of a major item is 15 to 20 percent less.

Second, cost and availability of an adequate supply of labor. This problem not only affects the price of the raw product, but also the cost of processing that raw product. It is an economic fact that labor costs are higher in an industrialized State such as Michigan. The cost of living is no doubt higher too. But this doesn't make it any less difficult for a food processor who must compete for workers in a hard-goods labor market. Improved efficiencies and greater mechanization must thus become the keynote of an operation such as ours in Greenville.

The third major problem area is the selling price of Michigan-produced finished product. As you may know, the selling price of the institutional product produced here is lower than that of one produced in Idaho. True, other producing States such as Washington and Maine do not enjoy an Idaho price either, but then their raw product costs are lower than Michigan's.

We don't believe that Michigan finished-product prices should be lower. The quality of both the raw product grown here and finished product processed here is as good as it is in any other area in the United States. But having quality and having the reputation for quality are not necessarily the same when it comes to the marketplace. Idaho has the reputation for quality. Unfortunately, Michigan did not. You will note that I said did not, for we believe Michigan's reputation for quality is growing and we are proud to be playing a part in developing that reputation. But there is a role that the Michigan grower and shipper must play in building this image, for it depends in large part on the State's reputation in the fresh-potato market. One of the major factors that made initial sales of institutional products produced in Michigan difficult was a generally poor reputation that the State had in the fresh market. And it takes time to overcome a poor reputation even if we all do the best job possible. We feel progress is being made and we are hopeful that Michigan will someday stand among those known as the "quality potato States."

At this point you may be saying to yourself that I am doing a lot of complaining about Michigan and that I have just given three reasons why a potato processor should not locate here. Let me assure you that these are not complaints. They are merely some of the problems as we see them. We are working toward their solution. We mention them in the hope that those of you interested in this State's agricultural economy will work with us.

Maybe now it's time I said some nice things about Michigan. I have already mentioned that the quality of the raw product our growers deliver is as good as any we receive. I should also mention that dealings with our Michigan growers have been among the most pleasant we have. We have been able to discuss our mutual problems openly and on a professional level. Many of the things I have said here today I have discussed on several occasions with our growers. They are a credit to Michigan agriculture.

We believe Michigan State University to be a leader in agricultural research, including that dealing with potatoes. It continues to be one of our prime sources of technical information.

Now, what about the future? Ore-Ida is committed to Michigan. We have several million dollars invested here and are adding to that investment with the addition of a "Tater Tot" line which will be ready for production this fall. Michigan grew only 42,000 acres of potatoes in 1968. Its proximity to the Nation's major population centers, combined with its potential for additional potato production, made it a good place to be. And, as we move to the solution of our problems, we think it will be even better.

PRELIMINARY REPORT ON THE RELATIONSHIP BETWEEN PROTEIN CONTENT OF POTATOES AND RESULTS OF BIOASSAYS

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Most of us know the history of the potato, and how it has served man as a basic food. Its value as a total food was brought to our attention most emphatically by the catastrophies resulting from the potato famines of Ireland in the 1840's.

It remained for Salaman to show its true food value in his book, "The History and Social Influence of the Potato," which parallels the introduction of the potato into Europe with the industrial revolution. Here was a crop capable of feeding many more people than was required for its production. People could leave the land and live in the cities and towns and have adequate food. As society became more affluent, dependence upon the potato lessened. However, it was a staple food of our forefathers when they were developing the continent. It can still be an important food source in developing countries where food shortages exist. The dietetic value of the potato--its worth as a food--has long since been established by experience, but only in more recent years has science confirmed this popular verdict.

The main constituents of potato tubers vary widely in quantity between methods of analysis, between varieties, and within varieties from one location to another. Simple chemical analyses show the potato to be a rather poor source of protein. Different researchers report wide differences in their analyses. They average approximately 2 percent, but range from 0.7 to 4.6. With such variability, especially in varieties, there is no reason to believe that the protein content cannot be improved.

To evaluate some of our clones we have been supplementing chemical analysis with bioassay using our colony of field voles (*Microtus pennsylvanicus*).

The field vole is very efficient for this purpose. It is entirely herbaceous. Unlike the rat, which is primarily a seed or high energy food eater, the vole makes good use of fiber. The weanling vole grows rapidly, and results are available in 6 to 7 days. It performs best on a diet of 14 to 20 percent protein (casein), minerals, vitamins, and fiber. On this diet the vole gains approximately one gram per day. From a chart, in data soon to be published, it is possible to predict the rate of growth from a wide range of combinations of protein, carbohydrates, and fiber.

In our early trials the diets were made with raw potatoes. Assuming perhaps 5 percent protein in the potatoes, the diet was supplemented with 7 percent protein from casein, vitamins, and minerals. Differences in growth between voles on the potato diets and those on the controls were insufficient, so the 7 percent supplemental protein was deleted. This left the potato as the only source of protein. The good clones can be easily recognized from the growth rates shown in Table I. From our growth charts the normal growth should be 0.4 ± gm./day.

TABLE I.--Nutritive value of selected dehydrated potatoes

Clone	Kjeldahl protein	Total grams gain in 7 days *Microtus pennsylvanicus*
5923-1	12.77	0.0
177	11.97	-1.5
5287-2	9.98	-1.75
5281-6	9.31	+1.25
5287-2	9.18	-1.0
62	8.78	+2.5
5279-4	8.51	+2.0
5336-7	8.38	+1.5
5279-21	7.98	-1.5
1022	7.58	+1.25
5820-5	7.18	-1.75
114	6.65	-1.5
5300-2	6.52	-1.0
92	5.72	-1.25

It is of interest to note that the voles consistently lost weight on some clones and, in the extreme, died. Since the potato is a solanaceous plant, such substances as alkaloids or inhibitors might be one of the causes for the poor growth rate. On the other hand, it might be attributed to the fact that the potatoes were raw, a state in which they are not normally consumed. To determine whether cooking would make a difference, two additional tests were conducted with clone 177, which was among those on which the voles lost weight. Each of these were 7-day tests in which two voles were fed raw potatoes and two were fed cooked potatoes. The voles on the cooked potatoes showed good growth rates; in one test the mean growth was 5 grams and in the other it was 3.25 grams. Both voles died in the first test using the raw potatoes, while in the other test one died and the other lost 0.5 gram.

A major problem has been protein analysis of the potato. This is being investigated at the present time. Also, feeding trials are now underway with dehydrated potato flakes made from our own clones. To date we are certain of variability between potato varieties. We are confident that the protein content can be increased. Our biggest and most time consuming task is evaluation.

SOME RECENT DEVELOPMENTS IN POTATO PROCESSING

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The potato takes an important place among the agricultural crops of most European countries. Since the Second World War, however, consumption of potatoes has gradually been decreasing. In 1946 the annual consumption in Holland amounted to more than 150 kg. (about 330 lb.) per capita. In 1950 this was down to 125 kg., and in 1960 the per capita consumption was only about 90 kg. A similar decrease in potato consumption has occurred in the other Western European countries.

At the beginning of 1960 the potato-processing industry started to develop, and this industry is still expanding. Still, after 1960 a gradual decrease in consumption of fresh potatoes prevailed, but this decrease was compensated for by an increase in consumption of processed potato products.

The development of the potato-processing industry in the Netherlands is shown by the following production figures (4):

1960	approx.	30,000	tons	1964	approx.	110,000	tons
1961	"	50,000	"	1965	"	130,000	"
1962	"	75,000	"	1966	"	150,000	"
1963	"	90,000	"	1968	estimated	200,000	"

A further expansion of potato processing into french fries, chips, dried potato products (flakes, granules, dice), canned potatoes, etc., may be expected in the future.

For more than 10 years the Institute for Storage and Processing of Agricultural Produce (IBVL) at Wageningen has been conducting research in the field of potato processing,and we have been carrying out storage research for more than 20 years.

In the first place we are investigating the requirements that potatoes should meet for processing into chips, french fries, potato powder, etc., and we are also searching for measures to be applied in order to meet these requirements. The last few years the IBVL has been carrying out quite a lot of technological research for the potato-processing industry. The object of this research is to make the industry less dependent on the quality characteristics of potatoes. Development of new potato products and the waste-water problem have also been undertaken. We are carrying out this research in close cooperation with the industry in Europe.

In my paper I will try to give a short review of some recent technological developments in potato processing.

Potato Storage

Potatoes are usually stored with outside-air ventilation. The principle of potato storage in Europe is quite similar to the American way of storage. There is, however, a significant difference: the ventilation capacity. Storage bins cooled by means of outside-air ventilation require a ventilation capacity of about 100 cubic feet/footpotatoes/hr. (3). This is more than twice the capacity applied in the United States. This large ventilation capacity is a necessity in most of the European countries because of climatic circumstances and the condition of the potatoes during harvest (potatoes are often brought into the storehouse rather wet and with much soil adhering to them).

In the first place, a large ventilation capacity is required for drying the potatoes as quickly as possible immediately after harvest, thus preventing blight and bacteria rot from spreading.

Secondly, a large ventilation capacity makes it possible to bring the potatoes to the right temperature quickly. This is particularly important when storing the potatoes till late in the season.

In general, the objection is raised that a large ventilation capacity implies a high weight loss. Investigations at the IBVL proved, however, that this need not be so by any means, as shown by Tables I and II.

TABLE I.--Weight loss of freshly harvested potatoes after equivalent periods of storage and time of ventilation (8)

Ventilation		Weight loss (percent)			
Capacity (cu.m./sq.m./hr.)	Time started (days after harvest)	Number of days after harvesting: 10	20	30	40
600	0	3.4	4.1	4.4	4.7
300	0	3.6	4.2	4.5	4.6
300	20	1.4	1.6	3.0	3.4

TABLE II.--Weight loss at different ventilation capacities of Bintje potatoes stored at 3 to 4 degrees C. (October 1 to April 1)

Ventilation			
Capacity (cu.m./cu.m./hr.)	Hours ventilated with outside air	Cooling air (cu.m./sq.m. of floor area)	Weight loss (percent)
100	175	61,200	3.27
75	238	62,500	3.26

It is of particular importance for a potato processor to have a large part of his potatoes stored at the plant so that he has a better control of storage conditions. It is also very important that the potatoes can be conveyed into the production line directly from storage to minimize physiological changes in the potato tuber. We know that the way potatoes are handled can increase their respiration and result in considerable sugar formation. Especially the reducing sugar content of potatoes affects the quality of most products into which they are processed.

Also, occurrence of blackspot can be checked to a large extent by processing potatoes immediately after handling (4).

In Europe it has been found that the quality of potatoes changes least during storage when proper insulation, good air circulation, and a large ventilation capacity are available.

Potatoes used to be stored in Europe in 50- to 100-ton bins. Present trends are, on the one hand, to store them in still bigger units, while on the other hand the units are getting smaller again, as a result of development of storage in pallet-boxes. Figure 1 shows the system developed for storage in pallet-boxes (1). This ventilation system keeps the potatoes in good condition by forcing the air through them via the pallets. An important development in storehouse construction is prefabrication. A prefabricated storehouse is built up from prefabricated elements, consisting of two aluminum layers separated by polyurethane foam for insulation (2). Already several of these storehouses have been established in Holland, and it appears that investment costs are considerably less than for building a conventional storehouse.

Vacuum Frying of Chips

In the potato-processing industry not only the exterior quality of the potato is of importance, but its interior characteristics as well. Especially the reducing sugar content in the potato is of significance for most processed products.

In order to keep this reducing sugar content as low as possible, many measures can be taken, e.g., using the right variety, growing a mature product, storing the potatoes at high temperatures, reconditioning, etc.

The chip industry makes the most severe demands for potatoes with low reducing-sugar content. These demands considerably increase the cost of potatoes for chipping,and they often cannot be complied with in practice. During the frying process the reducing sugars react with amino acids (Maillard reaction), resulting in a brown discoloration of the chips and a bitter taste. The higher the reducing-sugar content in the potato and the frying temperature, and the lower the moisture content in the final product, the more severe is the browning by this Maillard reaction. The technological department of the IBVL has now developed a new frying method: the chips are fried in a conventional cooker until they reach a moisture content of 8 to 15 percent, then they are finish-fried under vacuum till the moisture content is reduced to less than 2 percent (9, 10).

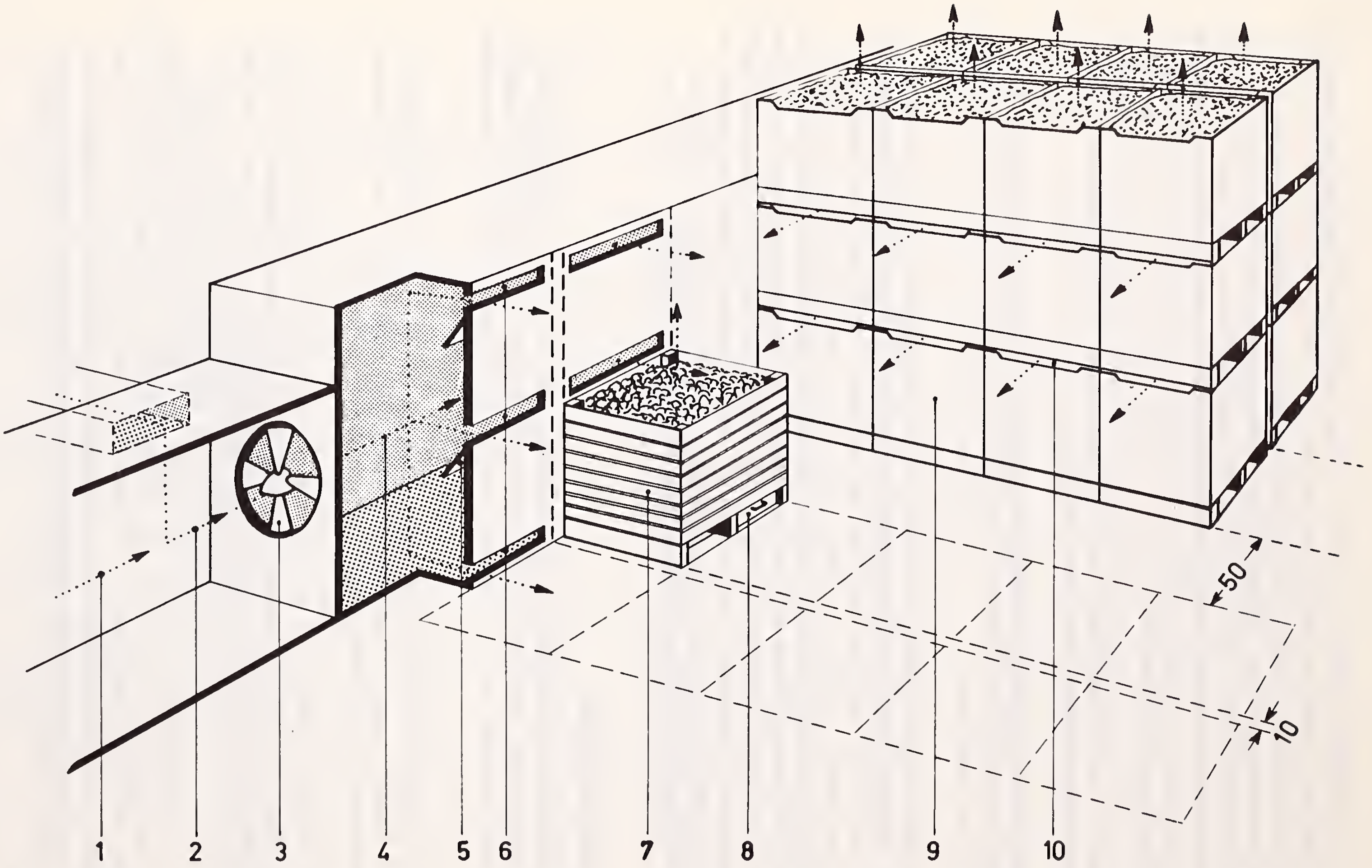

Figure 1.--Ventilation system for potatoes stored in pallet boxes.

1. Unheated outside air.
2. Heated air.
3. Fan.
4. Mixture of outside air and heated air (if necessary).
5. Hatches to shut off air from the air channel.
6. Air vents
7. Box containing f. e. potatoes (sides of open latticework)
8. Boards.
9. Boxes with closed sides containing grain or other seeds.
10. Air vents.

This method of vacuum frying chips provides a constant high quality throughout the whole year, irrespective of the reducing-sugar content (up to 0.8 percent) of the processed potatoes. Vacuum frying has the advantage of lower costs for raw material, easier storage, and lower production losses.

At the National Potato Utilization Conference in Corvallis last year, Ir. Sijbring gave a paper about this method of frying, in which the details of the oven were described (10). In the meantime, 7 vacuum fryers have been installed, 4 of which have been running for some months now.

Apart from a few problems at the start, these machines are now operating satisfactorily. Vacuum frying cannot only be applied to make chips, but potato sticks as well. The capacity of the standard vacuum fryer is 2000 lb./hr. Dimensions and data of this vacuum cooker are as follows:

Capacity	2000 lb./hr. Input moisture content: 10 percent for chips, 20 percent for sticks
Installed electric power	Approx. 50 kw.
Control panel	24 V. - 50 cycles/22 V. - 60 cycles 700 VA.
Water consumption	Approx. 30 cu.m./hr. (6600 Brit. gal. or 7900 U.S. gal.) Pressure 1.5 kg./sq.cm. (21 p.s.i.) Temperature 12 deg. C. (53 deg. F.)
Compressed air consumption	Approx. 25 Nm.^{3}/hr. (5500 Brit. gal. or 6600 U.S. gal.) free air. Pressure 5.5 kg./cm.^{2} (80 p.s.i.)
Vegetable oil content	Approx. 5000 liters (1100 Brit. gal. or 1300 U.S. gal.)
Overall dimensions	Length (normal) 8,915 mm. (29 ft. 3 in.) (drawn out) 13,300 mm. (43 ft. 7-1/2 in.) Width 2,500 mm. (8 ft. 4 in.) Max. height 4,800 mm. (15 ft. 9 in.) Min. discharge height onto filling conveyor 4,650 mm. (15 ft. 3 in.)
Weight	17,500 kg. (max. weight when filled with water during cleaning)

New Method of Chip Frying

I presume you know there is a large difference in dry-matter content of the various potato varieties. There is, however, also a large variation in dry-matter content of the different potato lots of one variety. Even within one potato lot, tubers with a low and a high dry-matter content can be found. This is clearly shown in Table III (5).

TABLE III.--Average weight-percentages in the different specific-gravity ranges after classification of 61 samples in several underwater-weight groups (5)

Underwater weight (grams)	Number of samples	Average weight percentages					
		Specific gravity range:					
		<1.070	1.070 1.080	1.080 1.090	1.090 1.100	1.100 1.110	1.110 1.120
<350	4	38.2	36.7	23.3	1.8	--	--
351 - 360	2	27.7	34.1	31.8	5.9	0.5	--
361 - 370	7	17.4	38.-	30.6	13.6	0.4	--
371 - 380	10	15.1	31.6	40.9	11.1	1.3	--
381 - 390	11	8.5	27.3	45.9	16.8	1.5	--
391 - 400	10	8.1	18.7	48.7	20.3	4.-	0.2
401 - 410	13	4.-	13.1	48.3	29.6	4.9	0.1
> 410	4	1.8	6.3	43.6	37.8	10.3	0.2
Average	61	11.3	23.9	42.4	19.3	3.-	0.1

Here the dry-matter content in potatoes has been assessed by means of underwater weight. The potatoes have been classified in underwater weight groups, which have again been divided into specific gravity ranges by means of brine-bath separation.

In the potato-processing industry the main difficulties usually occur when using potatoes with a low dry-matter content. At some plants in Europe the potatoes within a low specific-gravity range are eliminated by means of brine-bath separation, giving a more uniform final product.

The variation in dry-matter content of the various tubers also causes problems in frying potato chips. When chips are fried, water is removed from the slices till the moisture content of the final product is less than 2 percent. It is quite evident that more water has to be removed from slices with a high moisture content than from those with a low moisture content. This means that in a good cooker the frying time of each slice has to be determined by the moisture content.

Following this principle, the Technological Department of the IBVL has developed a prototype cooker in which the slices are fried on the basis of their moisture content by a rotating oil flow. The oil is heated in a heat exchanger and then set in rotation in the actual cooker so that the chip slices that have been sufficiently fried are carried off by the oil flow. Slices still containing too much water remain in rotation till the water has been sufficiently evaporated.

Experiments with the prototype of this cooker have given promising results up till now, with each chip having about the same moisture content and a uniform color.

Dry Peeling of Potatoes

Another significant problem in potato processing is water contamination in peeling. In the processing of potatoes, peeling is an important operation. For most products it is necessary for the skin to be removed as thoroughly as possible. Manual labor in removing the peelings from potatoes must, however, be kept to a minimum to keep the cost down. Regardless of the peeling method applied, peelings are usually carried off with water. The peelings settle out from the water, but all their soluble substances remain in the water and can only be separated from it by application of methods that are very expensive.

In many industries these waste waters are disposed of somehow, somewhere, even though the soluble substances are not removed from it.

This problem is becoming more and more difficult to solve. Authorities have been diligently searching for methods to purify the polluted water as efficiently as possible. The time is certainly soon coming that each potato-processing plant will have to have its own biological (or other) purifying installation, and in many places this is already a "must."

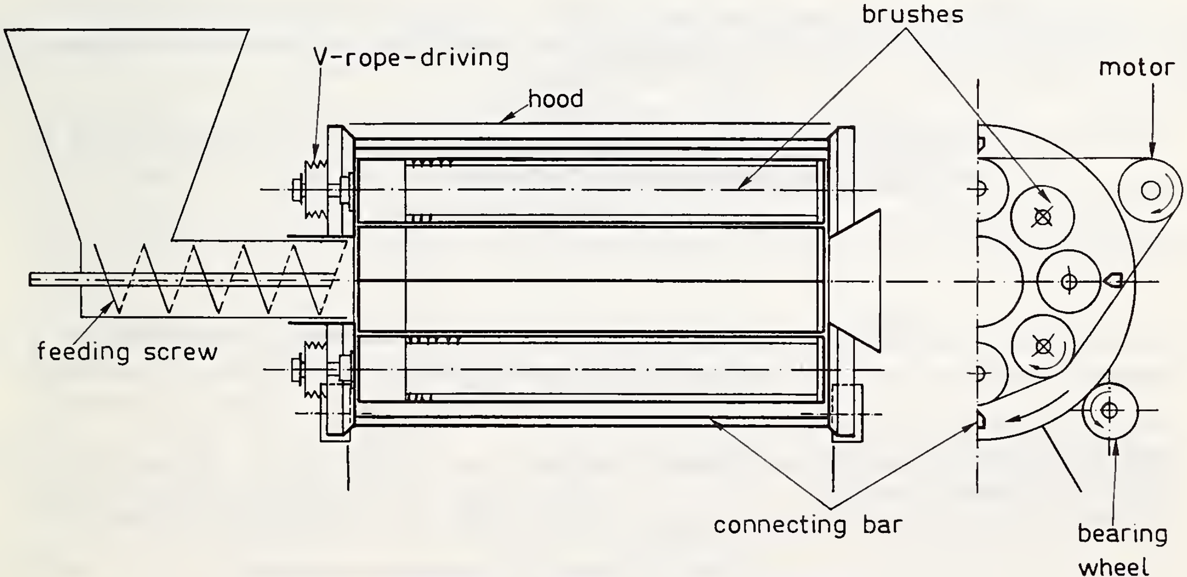

Figure 2.--Schematic view of the brushing machine

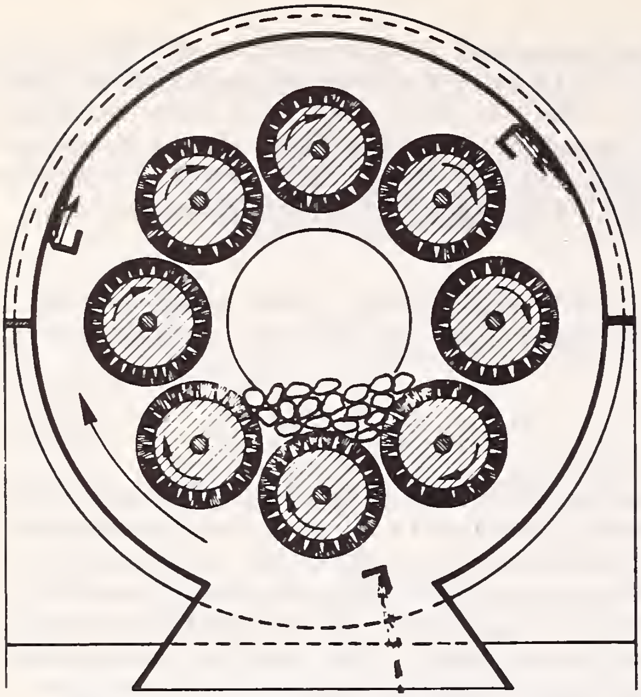

Figure 3.--Principle of action of the brushing machine

However, investments for such installations are high, and for this reason, people prefer to discharge the waste water into the sewer system in many cases. Even then, they will often have to pay a considerable amount. The charges for removal of the waste water are not the same in all countries, and certainly not in all cities. In the future these charges will increase rather than diminish, and as the water is more polluted the charges will be higher.

Cooperators of the IBVL have therefore examined the possibility of either preventing pollution of the waste water or considerably reducing it by applying special processing methods. One of the results of these investigations has been the construction of a brushing machine for peeling potatoes (11, 12). This machine brushes off the skin of the tubers without using water. The principle is shown in figures 2 and 3. The drum as well as the brushes rotate with the speed adjusted in such a way that the peeling remnants are discharged while the tubers remain in the drum. The skins that are carried off are more or less wet.

This method has been tested at lye-peeling as well as steam-peeling installations (6, 7). Use of this machine for steam-treated potatoes has the additional advantage that the skins are suitable for cattle feeding, since they are just steamed potato tissue.

Experiments have been carried out at a plant with two steam-peeling lines next to each other. A brushing machine was installed in one of the lines, and water contamination in both lines was measured. The results are given in Table IV.

TABLE IV.--Comparative contamination of waste water in steam peeling of potatoes by washing and by brushing (11, 12)

Item	Removal of the skin by	
	Washing	Brushing
Water usage (cu.m./ton)	21.7	12.1
Contamination (population equiv./ton/day)	190	48
Peeling losses (percent)	17.3	19
Solids removable by sedimentation (cu.m./ton)	0.890	0.130

It appears from these tests that brushing results in (1) a reduction in the amount of sediment to be removed from the wash water (only 15 percent as much as in normal peeling); (2) considerably less contamination of the water after settling (the number of population equivalents falls to about 25 percent of that with normal peeling); (3) a great reduction in the usage of clean water. For the moment we assume that if the equipment is properly adjusted and the water is used economically, 1 cubic meter per ton of tubers will suffice.

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